BC hydro

# TWENTY-YEAR RESOURCE PLAN

*For the period 1989 to 2008*

April 1989

*proud of our Service*

B. C. HYDRO

# TWENTY-YEAR RESOURCE PLAN
FOR THE PERIOD
1989 - 2008

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# PREFACE

We are using a new report format this year designed to inform our growing public audience about the 1989 Resource Plan in a manner that is useful yet not too technical. The main body of the report presents a description of the Plan while Appendices I through VIII have been expanded to contain the technical details. We have also added a glossary to clarify any technical references used in the body of the report. For those seeking further information beyond the scope of this report, there is a list of relevant publications after the glossary of terms. We are grateful for all the comments received since the publication of the 1988 Plan and look forward to your response to this year's Plan.

The primary purpose of the Resource Plan has been to report the strategies and related actions necessary for B. C. Hydro to meet the needs of its customers in the future. We have updated the scope of this year's Plan to include more information useful to the many readers and customers who have an interest in resource planning at B. C. Hydro. We begin with a review of events in 1988 that relate to B. C. Hydro's role in the energy community. The reader will get a glimpse of the dynamic environment which is the platform for our planning activities. The resource planning process itself is described in Section 2, while Sections 3, 4 and 5 provide some specifics on marketing and resource development.

We recognize that some of our readers may be looking for assistance with their own planning activities. While this report presents a static picture of the Resource Plan, the Plan itself is dynamic and is updated as information becomes available. Upon request, we will be happy to inform our readers about significant variances, if any, between the most current Plan and the latest report. Please call our Resource Planning Department at (604) 663-3013.

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# SUMMARY

## PURPOSE

The 1989 Resource Plan is a document about electricity supply planning in British Columbia. The information presented is useful not only to B. C. Hydro but also to others involved in energy resource development in this province. As Hydro's role in resource development continues to evolve, the plan has broadened its perspective to include all potential electric energy options available to British Columbia.

B. C. Hydro has a mandate to provide for the most efficient use of electrical energy resources while contributing to the economic development of the province. In the face of uncertainty, B. C. Hydro's plans must balance quality of service with rate levels; address environmental and regulatory concerns; and consistently optimize the supply, marketing and management of existing and planned resources.

## SHORT-TERM PERSPECTIVE

1988 marked the third consecutive year in which demands exceeded projections for the B. C. Hydro system, confirming British Columbia's strong economic recovery. The firm hydro surplus that existed since the early 1980's was almost totally absorbed during the year, while continuing success in marketing efforts both in the domestic and in the export markets allowed the sale of all other non-firm energy.

During 1988, the short-term emphasis on producing and using energy as efficiently as possible before committing to new developments was evidenced by the launching of "Power Smart", a program that will involve and benefit all customers. B. C. Hydro will also invest in existing generation facilities to obtain additional energy. Progress was also made in discussions with Alcan, Trans-Alta and the Bonneville Power Administration to secure agreements on coordination and long-term purchase of energy. Expressions of interest were sought from the private sector to finance, build and operate new capacity for the domestic and export markets. POWEREX, a new agency responsible for the marketing of electricity in the U.S. was established. A review of options regarding the future use of the Columbia River downstream benefits continued with the Provincial Government.

## RESOURCE PLAN

B. C. Hydro's 1989 Resource Plan is aimed towards achievement of competitive pricing through efficient use of resources, reliable power supply, appropriate mix of demand-side and supply-side options, appropriate mix of public and private development, acceptable environmental impacts, and acceptable and manageable financial risks. This year, however, the recommended sequence of new project development does not go beyond the early 2000's. The shorter time horizon is a reflection of the requirement for flexibility to incorporate potential impacts of recent policy changes over the mid and late 1990's, and also the need to review in depth the various development alternatives beyond the turn of the century.

### Recommended Plan

| | |
|---|---|
| Power Smart Programs | Ongoing |
| Resource Smart | Ongoing |
| TransAlta Coordination/Purchase | Under Discussion |
| BPA Coordination | 1989 |
| Purchases from Independent Power Producers | 1994 |
| Alcan Coordination and Energy Purchase | 1995 |
| Keenleyside — Murphy (Murphy Creek in-service later) | 1998 |
| Peace Site C | 1999 |
| Additional resources (e.g. Downstream Benefits) | Post - 2000 |

The timing of Keenleyside, Peace Site C and the next resource additions will depend on demand growth, the outcome of negotiations with TransAlta, the return or resale of the Columbia River downstream benefits (DSB's), and the contribution made by independent power producers. Murphy Creek is closely related to Keenleyside and while its timing has yet to be determined, the projects would proceed through licensing together.

The selection of additional resources to the system beyond the year 2000 has not been made, as B. C. Hydro will be undertaking during 1989 a comprehensive analysis and public discussion of the options available. The Resource Plan outlines the main attributes of three development strategies and their perceived strengths and weaknesses.

## FUTURE ACTIONS

The recent launching of Power Smart and the issuing of requests for proposals from the private sector, plus the ongoing nature of discussions with other producers require that B. C. Hydro maintain options available should current initiatives appear to be delivering below expectations and/or demands exceed projections. Several actions will be undertaken during fiscal year 1989/90 both to advance implementation of the Plan and to retain the necessary flexibility:

1. Promotion of Power Smart across the province, to build upon initiatives started in 1988, and to introduce key new programs.

2. A final agreement to be signed with Alcan for a twenty-year purchase and coordination beginning in 1995.

3. A formal agreement to be signed with the Bonneville Power Administration for coordinated operation of the reservoirs on the Columbia River.

4. Establishment of principles for an agreement on coordinated operation with the Alberta Integrated System.

5. Continuing evaluation of proposals from independent power producers and issuing of a second request for proposals later in 1989.

6. Preparatory engineering activities to continue on the Keenleyside and Peace Site C projects, as a significant element in B. C. Hydro's contingency plans to meet uncertain future demand growth.

7. Resource scenarios beyond the year 2000 to be evaluated, including Resource Smart program definition in 1989.

8. Dam safety rehabilitation/remedial work to continue during the year.

9. Work to be initiated on various transmission lines to allow purchases from Alcan and also to serve load growth in the Lower Mainland and Vancouver Island.

10. Depending on the success of marketing efforts in the U.S. and the expressions of interest received, POWEREX to issue later in 1989 a request for proposals for generation projects intended for export.

# INTRODUCTION

## PURPOSE

The 1989 Resource Plan is a document about electricity supply planning in British Columbia. The information presented is useful not only to B. C. Hydro but also to others involved in energy resource development in this province. The review of 1988 events presented in the report makes it clear that as Hydro's role in resource development continues to evolve, the plan must broaden its perspective to include all potential electric energy sources and options available to British Columbia.

Uncertainty is why we must plan. B. C. Hydro has a mandate to provide for the most efficient use of electrical energy resources while contributing to the economic development of British Columbia. The direction provided by recent policy initiatives placing emphasis on the efficient use of energy and the participation of the private sector in the energy production business will significantly alter Hydro's traditional role. These important events are in their own planning and launching stages, and the status of the various programs currently underway has had direct impact on the preparation of this report.

B. C. Hydro's plans must balance quality of service with rate levels; address environmental and regulatory concerns; and consistently optimize the supply, marketing and management of existing and planned resources. While these objectives are still fundamental, the recommended sequence of new project development for the 1989 Resource Plan does not go beyond the early 2000's. The shorter time horizon is a reflection of the requirement for flexibility to incorporate potential impacts of recent policy changes over the mid and late 1990's, and also the need to review in depth the various development alternatives beyond the turn of the century. The report highlights those activities required during 1989 to meet the ongoing objectives of the Plan.

This Resource Plan examines three basic development strategies beyond 2000. Although not mutually exclusive, each presents an emphasis on different sources to meet future electrical demands — hydro projects, thermal projects, or a combination of supply and demand management. The Plan addresses the main attributes of each development strategy and their perceived strengths and weaknesses, not only in terms of their relative economics but also broadly vis-a-vis other financial, social and environmental criteria. No recommendation is made on whether to adopt any of the suggested development strategies, as B. C. Hydro will be undertaking during 1989 a comprehensive analysis and public discussion of the options available. In this regard, the response from the private sector to B. C. Hydro's requests for proposals issued in the winter of 1988/89 will be an important first step in providing an indication of the role and potential contribution of independent power producers to meeting provincial electricity demands.

Given the Plan's twenty-year horizon and the dynamics within that time frame, it is necessary to evaluate not only the Plan, but also the planning process on a continual basis. We appreciated the many comments received from readers of last year's Plan and have attempted to provide more information about the topics of greatest interest.

## REVIEW OF LAST YEAR'S EVENTS

1988 marked the third consecutive year in which demands exceeded projections for the B. C. Hydro system, confirming British Columbia's strong economic recovery. Actual loads for the fiscal year ending 31 March 1989 will almost equal the B. C. Hydro hydroelectric system's firm energy capability, i.e. the firm hydro surplus that existed since the early 1980's will have been absorbed. Continuing success in marketing efforts both in the domestic and in the export markets, combined with water inflows somewhat below average for the year will also limit the availability of surplus hydro energy in the short term.

Thus, the main principles of B. C. Hydro's strategy outlined in last year's Resource Plan retain their full relevance today. B. C. Hydro's increased reliance on purchase and coordination agreements with other energy producers, added emphasis on the efficient use of existing resources through improvements to existing facilities, continuing support for demand-side management activities, and the recent initiatives encouraging the participation of private power producers should all contribute towards the goal of meeting future customer requirements efficiently and economically. Hydro's rates should continue to benefit from the postponement of large expenditures in new generation projects, which do not appear to be required until the late 1990's.

Several events took place during 1988 that underline B. C. Hydro's commitment to the above strategy:

- In July, Alcan and B. C. Hydro agreed upon principles for the coordination and long-term purchase of energy from Alcan's Kemano Completion Project.
- An energy efficiency strategy and accompanying marketing program named "Power Smart" was approved in August 1988, with the commitment of $7.5 million for 1988/89 and a budget of $225 million over the following ten years. An intensive advertising campaign was launched in March 1989, to explain to the public how they can participate and benefit.
- As intended in a document signed in October 1987, joint work with the Bonneville Power Administration continued during the year to complete an agreement in 1989 on the coordinated operation of the American and Canadian reservoir storage on the Columbia River.
- A program to obtain additional energy from existing Hydro generating stations through efficiency improvements and redevelopment, named "Resource Smart" was formally introduced in October.
- In December, expressions of interest were sought from the private sector to finance, build and operate up to 150 MW of new capacity for B. C. Hydro's Integrated System, and from existing customers who can release electricity through load displacement measures.
- POWEREX, a new agency responsible for the marketing and export of electricity was created in December. Shortly after, a request for expressions of interest from the private sector to develop up to 400 to 600 MW of power supply for export was issued.
- A request for proposals to purchase electricity from projects smaller than 5 MW, owned and operated by private producers, will be issued at the end of April 1989. The first agreement under this new policy has already been signed, whereby B. C. Hydro will purchase power for its integrated system from a 300 kW hydroelectric plant located 70 km west of McBride.
- In addition, progress was made in a number of other areas such as discussions with Alberta utilities to formalize a coordination and purchase agreement, and a continuing review with the Provincial Government of options regarding the future use of the Columbia River downstream benefits.

## REPORT STRUCTURE

The **Policy and Planning Framework** section outlines B. C. Hydro's role and objectives within the provincial economy, as well as the main assumptions and planning criteria adopted to evaluate alternative strategies. **Markets for Electricity** introduces B. C. Hydro's current demand forecast including a brief review of the impact of domestic marketing programs and the outlook for electricity exports. The section on **Potential Resources** reviews the options available to meet future load growth in the B. C. Hydro system with new projects, purchases, coordination agreements, independent power producers, improvements to existing facilities, and demand-side management programs, which are treated as a discretionary resource. The **Twenty-Year Resource Plan** examines the relative merits of three development scenarios on the basis of their economics, scheduling, environmental and other attributes, discusses the different decisions involved, and how the Plan could be modified in response to a variety of possible events. **Action Plan** lists the steps required during the coming fiscal year beginning 1 April 1989 to meet the Plan's overall objectives.

The Appendices have been expanded to include additional supporting data along with technical criteria previously reported in the main body.

# POLICY AND PLANNING FRAMEWORK

## 2.1 ROLE OF B. C. HYDRO IN THE PROVINCIAL ECONOMY

B. C. Hydro's objectives are consistent with those of the Province. Hydro's objectives of achieving the most efficient use of resources, maximizing the contribution to provincial economic development and providing superior customer service align closely with the Province's goals of economic growth, regional development, diversification, and concern for the environment.

Reliable and safe electric power at competitive rates provides B. C. industry with a comparative advantage it needs to contribute directly to economic growth in British Columbia. A coherent rate structure that reflects resource costs and encourages cost-effective private investment in power supply helps to fulfill the efficiency objectives. Extension of service to zones not currently included in the Integrated System and employment creation through local initiatives contribute to regional development. Stringent waste management standards are applied to limit impact on the environment. Each major project includes an environmental impact assessment which is reviewed by regulatory bodies and the public. Concern for the environment is ongoing and will figure prominently in the development of an appropriate resource mix.

As an energy producer and a large corporate citizen, B. C. Hydro distributes the benefits of hydroelectric development throughout the province. Everyone receives the benefits of low Hydro rates, currently among the lowest in the world. The payments of water rental fees, taxes and grants are essential to the operations of civic and provincial authorities. As a large corporation providing employment in many areas of the province, Hydro contributes to community life, while maintaining a standard for other employers to emulate. Special incentive rates, designed to encourage economic development, reinforce Hydro's commitment to being a driving force. Construction-related employment and flood control provided by hydro dams also benefit local communities.

Electricity has a vital future role to play in the provincial economy and will remain a major asset for British Columbia. With appropriate pricing, electricity will continue to capture an increasing share of the energy market. The industrial and commercial sectors will benefit through increased energy use efficiency. In particular, forecast strong growth in resource processing (pulp and paper, smelting, refining, and chemicals) will depend on competitively priced electricity.

## 2.2 OBJECTIVES OF INTEGRATED RESOURCE PLANNING

### DEFINITION

Integrated resource planning is used by utilities and regulatory commissions to assess a variety of resources to meet customer energy service needs cost-effectively. The process has been characterized as follows:

- Considers a broad range of supply, demand, transmission, and rate-design options.
- Identifies and analyzes the key factors that are uncertain and that affect resource-

acquisition decisions.

- Requires substantial involvement from customers, regulators, and energy experts.
- Implements a short-term action plan within the context of the long-term objectives.
- Maintains an ongoing review and adjustment of the plan as events and opportunities change.

B. C. Hydro has largely adopted this approach and this Resource Plan reflects that perspective.

## OBJECTIVES

The objectives of integrated resource planning, as they determine the nature of power supply development in B. C., can be summarized as follows:

- Competitive pricing through efficient use of resources.
- Reliable power supply
- Appropriate mix of demand-side and supply-side options.
- Appropriate mix of public (B. C. Hydro) and private (independent power producers) supply.
- Acceptable environmental impact.
- Acceptable and manageable financial risks.

Achievement of these objectives requires a set of decision criteria consistent with the role and mission envisaged for the utility. In this regard, the Resource Plan is a key element towards meeting B. C. Hydro's objectives and its formulation has to reflect a careful balancing of potentially conflicting criteria. An ongoing consultation process involving government, regulatory bodies and the public should help develop guidelines consistent with the community's views on issues such as the environment.

Because the future facing utilities is almost certain to bring major changes, phrases such as uncertainty, risk, diversity, and flexibility are frequently raised in discussions of resource analysis, planning and decision-making. Agreement is also needed among utilities and regulatory commissions on how to balance risk against cost in shaping utility decisions. Factors that affect such decisions can be divided into two categories: external factors, which are largely outside the control of the utility, such as inflation rates, regional economic growth, and the prices of fossil fuels; and internal factors, at least partly under the control of the utility, such as construction schedules, operation and maintenance costs, and marketing of demand-side programs.

B. C. Hydro's objectives will also be coordinated with those of POWEREX, the provincial agency responsible for electricity exports. POWEREX will be soliciting development proposals from independent power producers for new resources to meet long-term export markets. Resources will not be developed for the export market to the detriment of domestic customers.

## 2.3 DECISION CRITERIA

This section outlines the main policies, assumptions and economic and technical planning criteria adopted by B. C. Hydro in the formulation of the Plan. Technical criteria are required to ensure that adequate quality of service is provided to customers, while economic criteria ensure consistency with overall economic and financial goals for the utility. In addition, environmental, social and other policy considerations influence project selection and investment decisions. The underlying assumptions behind the planning criteria are reviewed and modified from time to time to reflect changing conditions.

### 2.3.1 CORPORATE POLICIES

- **The Environment:** B. C. Hydro has adopted an Environmental Policy, which aims to minimize the adverse effects of Hydro's operations on the environment and to pursue resource enhancement where opportunities exist.

  In order to reach these goals, B. C. Hydro is committed to assessing the environmental and social implications of the potential projects presented in its resource plans. In particular, efforts are directed towards reducing adverse impacts wherever possible. Where this cannot be adequately achieved, B. C. Hydro will initiate compensation programs to restore or enhance impacted resources. In addition, B. C. Hydro will actively promote and support the concept of multiple use of its reservoirs and other facilities. In establishing these programs, B. C. Hydro will work through a consultative process with the various levels of government and the public.

  Environmental criteria are included along with technical and economic criteria in all phases of project development. Potential new projects in the Resource Plan incorporate features aimed at minimizing environmental change. B. C. Hydro's environmental policy will be elaborated in May, at the second Electric Energy Forum in Vancouver. A more detailed policy statement is contained in Appendix I.

- **Independent Power Producers:** The provincial government has indicated that it supports private sector participation in the provision of new generation. B. C. Hydro has been looking at non-utility supply options to meet future demand growth, and as a result, several requests for proposals were issued in the last few months. B. C. Hydro intends to purchase electricity from independent power producers selected through a competitive bidding process, and also encourages increased industrial self-generation, including cogeneration. This policy is in its early stages of implementation. (See Section 4.4 and Appendix VI for further details.)

- **Export Market and Free Trade:** All exports of electricity from B. C. will be channeled through a single-window agency, POWEREX. Revenues from short-term sales from B. C. Hydro resources will be collected by POWEREX and B. C. Hydro will be reimbursed for costs, and also, in part, for the market value of the service provided.

  Longer term exports which require construction of new resources will also be handled by POWEREX. Such exports will be provided from generation resources developed primarily by independent power producers, although B. C. Hydro will provide support services such as wheeling, standby capacity, and shaping on a cost reimbursement basis.

(See also Section 3.3 "Export Market Outlook".)

The Free Trade Agreement did not confer any new benefits to Canadian electric utilities, but it should preempt American competitors from pressuring Washington to erect tariff barriers that would cut into POWEREX exports.

- **Wheeling:** Recent amendments to the Utilities Commission Act (Bill 46) enable the B. C. Utilities Commission to order a public utility to allow other parties to use the utility's transmission facilities when it is in the public interest and does not adversely affect the utility's service.

  This transaction, commonly referred to as "wheeling", facilitates a greater role for independent power producers in meeting new provincial electricity requirements. B. C. Hydro is developing a wheeling policy in consultation with the provincial government, to facilitate economic wheeling.

### 2.3.2 ECONOMIC AND FINANCIAL CRITERIA

Evaluation of capital, operating, energy purchase and other costs associated with each alternative development program is carried out using the discounted cash flow method. In addition, revenue requirements and impacts on future rate levels arising from different plans are examined. The following parameters have been used:

- **Discount Rate:** One of the most important parameters for the corporation to guide its investment strategy, the choice of a discount rate is critical as an instrument of policy. A review carried out during 1988 concluded that a 6% rate (net of inflation) represents the cost of long-term provincial borrowing, which is the minimum net return B. C. Hydro is to achieve to avoid financial losses. Higher rates, in the 7 to 8% range, represent the weighted average return from public and private investment in Canada, and should be used to measure benefits and costs to the economy as a whole.

  Studies for this Resource Plan have utilized a range of discount rates of 4%, 6%, 8% and 10%. The background and rationale behind the selection of appropriate discount rates for B. C. Hydro is contained in Appendix I.

- **Financial Impacts:** The discounted cash flow methodology enables a consistent ranking of projects which have different service lives and profiles of capital and operating costs. However, minimizing the net present value (NPV) of costs is not the only economic or financial objective. Projects requiring a large initial capital investment may be attractive in NPV terms due to long service lives and low operating costs. But servicing the debt on such large investments may increase revenue requirements in the short term above those from alternatives such as power purchases or efficiency improvements. A balance between the short and long-term objectives needs to be struck to the benefit of B. C. Hydro ratepayers, and this may lead to a mix of resources. Appendix I addresses this issue further.

- **Electricity prices:** They do not enter explicitly in the comparison between alternative plans, but they influence the demand outlook. Energy price projections are contained in Section 3.1 ("Demand Forecast"), and Appendix III.

- **Cost information:** Unless otherwise indicated, all figures are in 1988 uninflated dollars.

- **Taxes:** Water rentals, grants and school taxes paid to provincial and municipal governments have exceeded 18% of electric service revenues, on average, over the last three years. See Appendix I for further details.

- **Corporate Overhead:** B. C. Hydro projects are allocated a portion of overhead costs set as a percentage of total project costs. See Appendix I.

- **Operating Costs:** Fixed operating costs are based on B. C. Hydro's past experience. Fuel costs are primarily based on oil and gas price projections. See Appendix I for details.

- **Socio-economic Factors:** Employment, contribution to provincial economic growth and regional initiatives may be quantified and used in the evaluation of alternatives.

### 2.3.3 TECHNICAL PLANNING CRITERIA

- **Existing B. C. Hydro system:** The annual output of B. C. Hydro's existing hydroelectric system can vary between about 42 500 GWh and 52 000 GWh depending on streamflow conditions. In addition, some 3700 GWh can be provided by thermal plants (Burrard and gas turbines), as required to meet demands in the integrated system. Interconnections with other energy producers allow purchases from Alcan, TransAlta and the U.S., if required.

  The total average cost of operating the system (including depreciation, taxes and finance charges) is currently about 4.2¢/kWh. The cost of operating the hydroelectric plants, which make up 90% of existing resources is essentially fixed, with most of it going to cover depreciation and interest charges. Their variable cost is about 0.4¢/kWh to pay for water licence fees.

  Further details on the technical characteristics of the B. C. Hydro existing integrated system can be found in Appendix II.

- **Resource Scheduling:** Plant additions and energy purchases are scheduled so that the expected cost of meeting domestic energy demands over the long term is minimized. A probabilistic approach is used which considers numerous combinations of demand forecasts, hydroelectric system streamflow conditions, energy purchases, demand-side options and other resources. Alternative plans selected must provide sufficient flexibility to meet a range of demand forecasts, but in some adverse combinations of loads, water conditions and resource availabilities, not all demands may be served. The probability and size of such deficits is a measure of the risk inherent in each alternative plan. Project advancements or deferrals may be required to meet higher or lower load growth beyond the typical lead time of about ten years for major projects.

- **Reliability:** B. C. Hydro requires both that an adequate capacity margin to meet peak loads be maintained and that the energy shortfall in any future year must be less than a certain percentage (0.8%) of the total annual energy demand.

- **Transmission:** Much of the transmission system has been built to integrate the generating plants. System strengthening through station and circuit additions will be necessary as domestic requirements increase. The transmission system is designed to be capable of withstanding high-stress conditions, including some outages. Performance standards relating to maximum line loads and security of service are also to be met.

- **Risks:** Numerous risks affect the choice between alternative development programs. The most common are related to demand/supply mismatches, which may have a more severe impact on investment in large, capital-intensive projects; cost overruns (less likely on standard, "off-the-shelf" projects); regulatory delays which affect in-service dates; failure of purchases from other utilities and independent power producers to deliver planned amounts; high inflation, which may cause borrowing costs to escalate; and technological progress, which renders plant uncompetitive or obsolete before the end of its projected service life. Section 5.4 explores B. C. Hydro's potential response to some supply risks.

Appendix II discusses in more detail the technical criteria currently used to plan resource additions to the existing electric system.

- **Lead times:** The elapsed time for major projects from start of investigations through project licensing to completion of construction varies from a minimum of 6-8 years to a maximum of 12-15 years. (See section 4.6)

# THE MARKETS FOR ELECTRICITY

## 3.1 B. C. HYDRO DEMAND FORECAST

Projections for electricity requirements within B. C. Hydro's service area are prepared annually, for a period extending twenty years into the future. The information contained in this section has been obtained from B. C. Hydro's report "Electric Load Forecast 1988/89 to 2008/09".

### ASSUMPTIONS FOR PROBABLE FORECAST

(i) The Economy

The B. C. economy is forecast to average 3.0% real annual growth over the ten-year period to 1998, and 2.8% in the following ten years. The main growth sectors through 1998 in the industrial area are projected to be paper and allied products manufacturing, non-resource based manufacturing, and construction. In the commercial area, community, business and personal services is expected to be the highest growth sector.

(ii) Population Growth

Population growth of about 1.4% on an annual basis is projected through the twenty-year period.

(iii) Energy Prices

Electricity prices are projected to decline in real terms by 1.5% per year for the first ten years and increase at the rate of inflation thereafter. The result is a projected real price decline of approximately 14% by 1998. Natural gas and light fuel oil prices are projected to increase marginally in real terms. However, natural gas will maintain its competitive advantage over electricity for space and water heating throughout the twenty-year period.

### PROBABLE ELECTRIC FORECAST

(i) Short Term Perspective

Following a recessionary period between 1981 and 1983, electricity sales on B. C. Hydro's system increased at an average annual rate of 4.6% over the four year period 1984/85 through 1988/89, underlying rapid economic growth and the considerable expansion experienced by the electric intensive forestry and mining sectors.

The short term indications are that electricity demand growth through 1991/92 will continue to average in the 3.5% to 4.0% range, above the 1988 forecast trend, reflecting the buoyant economy, in particular the pulp and paper sector.

There is no reason, however, to adjust the longer term forecast (averaging 2.8% per year) at this time. Long term economic projections have not changed significantly. Expansion in the electric intensive forest industry is limited by the allowable annual cut and thus new plants being developed today will be able to meet future requirements. The mining industry is projected to see a decrease in electricity consumption as some of the existing copper mines close, due to ore depletion.

(ii) Twenty-year Plan

Electric energy requirements within the B. C. Hydro Integrated System are projected to increase from approximately 42 300 GWh in 1988/89 to 55 290 GWh in 1998/99 and 72 410 GWh in 2008/09 for an annual average growth rate of 2.8%.

This is about 2400 GWh higher for 1998/99 than was forecast in 1987, even though the outlook for provincial economic growth has remained about the same. The two main reasons are: higher growth in electric intensive manufacturing areas such as the paper and allied products sector, and a continuous increase in the electric intensity of the commercial and some of the industrial users. The use of electricity has increased in industry as a means of achieving productivity improvements; adoption of conservation measures has been slower than antici- pated in the commercial sector. In addition, West Kootenay Power and Light forecast a requirement for support from B. C. Hydro in the future, and an allowance for this has been included in the B. C. Hydro forecast.

The forecast includes the impact of the firm domestic marketing programs discussed in section 3.2, but excludes consideration of the Power Smart customer programs, which together with investments in load reduction, are factored into the supply side of resource planning. Electric Plus is also excluded, given its interruptible nature. (See Section 3.2)

### FORECAST UNCERTAINTY

In addition to the probable, or most likely, forecast, a range of forecasts is developed. This represents an attempt to quantify the combined impact of variables such as economic conditions, energy intensity, population growth. Exhibit 3-1 depicts the various forecasts for the integrated system. There is a 50% probability that load requirements will be within the shaded area, and a 90% chance that actual growth will be between the high and low forecasts, at 4.2% and 1.1% average annual growth rates respectively. While the degree of uncertainty appears very large, history suggests that unforeseen circumstances can, and do, cause major changes in demand growth patterns.

Further details on B. C. Hydro's demand forecast can be found in Appendix III.

## 3.2 DOMESTIC MARKETING PROGRAMS

B. C. Hydro's emphasis on the efficient utilization of existing facilities at a time of energy surplus, combined with the utility's objective to support economic activity in the province led in the mid- eighties to the successive development of various marketing programs. This section outlines the status of the firm and interruptible programs currently in operation and planned for the future, with the exception of the Power Smart programs, which are treated as a resource option in section 4.1

### FIRM INDUSTRIAL MARKETING PROGRAMS

Sales under two of the programs remain operational. The Industrial Electricity Rate Discount Act (Bill 28) promoted increased production, expansion and new industry (primarily in the mining and chemical sectors). The Critical Industries Act (Bill 31) was a vehicle for reopening or keeping open industries in B. C. through electricity rate discounts which were part of a package of taxation, labour cost and other concessions. They added sales in the range of 1000 to 1600 GWh/year since their introduction in 1984 and 1985.

These programs will be winding down over the next two to three years. Estimated demands can be found in the Load Forecast document referred to in Section 3.1

### INTERRUPTIBLE MARKETING PROGRAMS (Electric Plus)

The intent of the programs, launched in the summer of 1987, is to market a portion of the system's surplus secondary electricity on an interruptible basis, at reduced rates to domestic customers currently using another fuel. (Secondary energy is that which is normally available on an annual basis above the firm, or minimum assured, supply.) Customers would be interrupted when sufficient water was not available, due to low water conditions. Coordination agreements for improved operation of the B. C. Hydro system will reduce the availability of secondary energy and thus, maximum potential sales under the Electric Plus programs have also been reduced. A maximum approaching 500 GWh/year is expected to be sold under this program. About one half of this will come from customers switching from another fuel. The remainder is the result of existing electric customers transferring from firm to interruptible service.

The **Residential Program** involves the addition of electric space or water heating with maintenance of the present fuel-fired system (oil, propane, butane, wood or coal) as backup. Existing electric heating systems may also qualify for the rate by adding an appropriate backup system. The **General Program** is intended for commercial and industrial customers and is available for space heating, water heating, and industrial process heating where a permanent backup heating system is maintained which uses oil, propane or a solid fuel.

Further details on load additions by program can be found in B. C. Hydro's Electric Load Forecast.

### ECONOMIC DEVELOPMENT RATE PROGRAM

In cooperation with the provincial government, B. C. Hydro will be introducing in the Spring of 1989 a program supplying power at reduced rates to encourage economic development and to provide an incentive for industrial and commercial diversification. This program underscores B. C. Hydro's objective to contribute to the economic development of British Columbia.

The Economic Development Rate Program will be limited to a cumulative total of 1000 GWh/year until the mid-1990's. It will offer power at a floor price below B. C. Hydro's bulk industrial rate. The duration of the program will be individually negotiated, but will not go beyond the mid-1990's. Economic development rates will be available only for production of new goods, or for those that would displace imports, to ensure that there will not be competition with existing operations within the Province. The Ministries of Energy and Regional Development will administer the program, in consultation with B. C. Hydro.

## 3.3 EXPORT MARKET OUTLOOK

As a result of an initiative by the provincial government, B. C. Hydro has recently established a subsidiary, called POWEREX, which will be the "single window" agency to market electricity to the U.S. POWEREX will take the lead role in negotiating and administering export sales agreements with U.S utilities and purchase agreements with electricity producers. B. C. Hydro will provide transmission access, shaping and standby services.

It is expected that U.S. export markets available to be served by B. C. resources will expand substantially over the next several years for the following reasons:

1. B. C. Hydro is planning to expand its transmission capacity to utilities in the U.S. Pacific Northwest.

2. Transmission access to U.S. Pacific Southwest markets is expected to increase due to upgrades in the capacity of the Pacific Intertie.

3. Market competition from surplus resources in the Pacific Northwest is declining due to load growth.

4. Resource information available from utilities in the U.S. Northwest and Southwest regions indicates that B. C. electricity resources will likely be cost-competitive with other alternatives.

During 1989, POWEREX will undertake a detailed assessment of the U.S. export market potential. Currently it appears that the market potential could be about 400-600 MW by the mid 1990's. This estimate is based primarily on discussions with Washington Water Power and Puget Sound Power and Light regarding possible transmission interties with B. C. Hydro. Discussions and planning activities on these interties will continue in 1989/90.

To assist in export market analysis, POWEREX will compile a list of potential resources available for export. As part of this process, POWEREX is seeking expressions of interest from independent power producers interested in supplying electricity for resale to potential export markets in the U.S. Independent power producers may include private sector companies in B. C. and electrical utilities other than B. C. Hydro. A pre-submission meeting held by POWEREX in January of 1989 attracted representatives of numerous companies. The expressions of interest will be received and evaluated in early 1989, and a short list of proponents should be available by the summer.

POWEREX and B. C. Hydro will also continue negotiations and discussions with BPA on coordinated operation of Columbia River reservoir storage, and on reducing current restrictions on transmission access for B. C. resources to U.S. markets via BPA's system. There will also be preliminary discussions on the potential resale of the Canadian share of the Columbia River Treaty downstream benefits which are scheduled to return to B. C. starting in 1998.

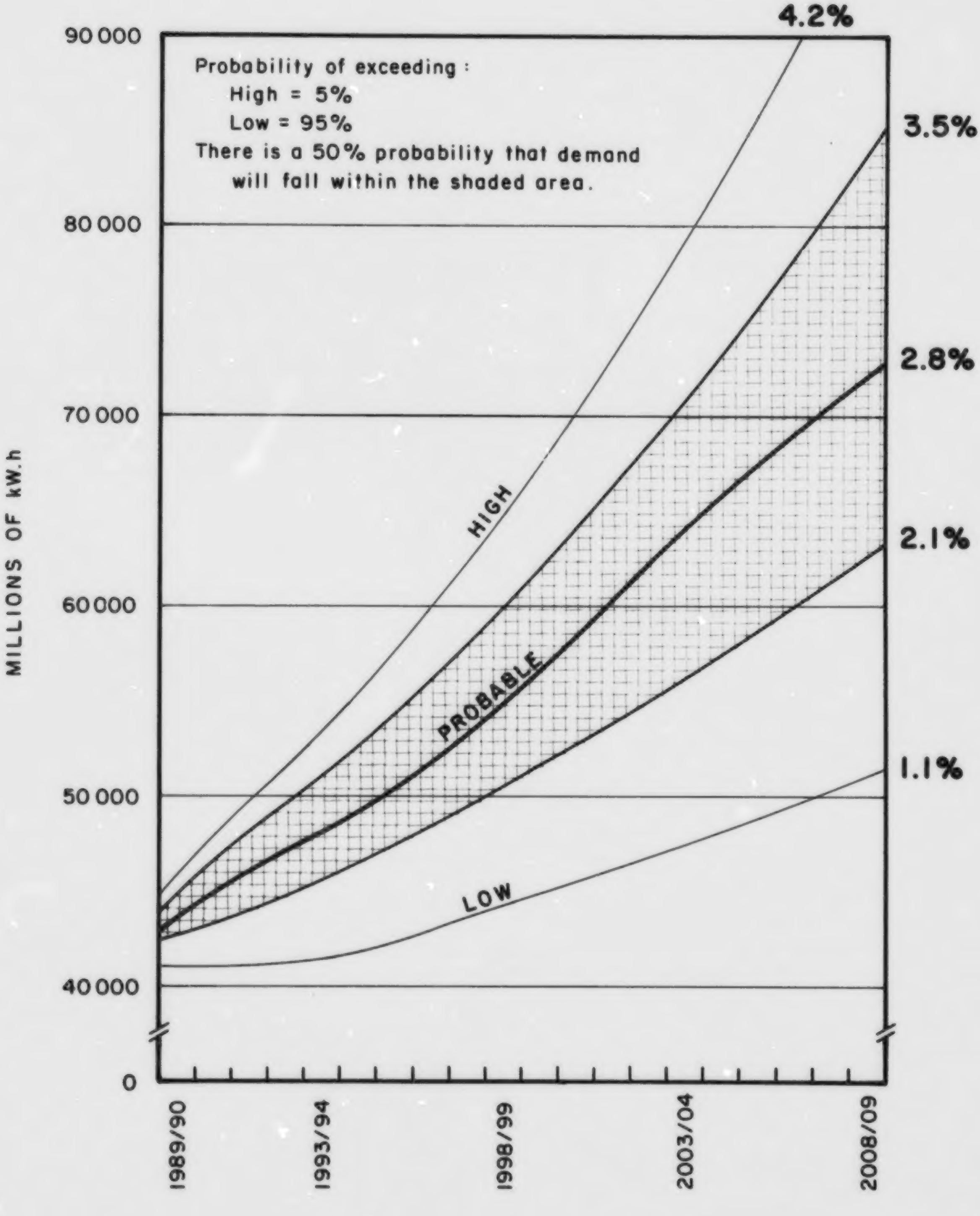
Short-term export sales are difficult to forecast because they depend on many variables, including precipitation, oil and gas prices, load growth, and the availability of surplus electricity in the Pacific Northwest. The current outlook is for moderate volumes of sales over the next three years ranging from 3500 GWh to 4700 GWh. Prices are expected to remain relatively stable at 1.8¢/kWh to 2.0¢/kWh for electricity at the Canada/U.S. border.

Sales in the export market have been as follows over the last 5 years:

| **Fiscal Year** (Apr-Mar) | **Export Sales** (GWh) | **Average Price** (¢/kWh) |
|---|---|---|
| 1984/85 | 6 378 | 2.9 |
| 1985/86 | 9 407 | 2.7 |
| 1986/87 | 4 665 | 2.0 |
| 1987/88 | 9 481 | 1.9 |
| 1988/89 | 4 884 | 2.1 |

EXHIBIT 3-1

# RANGE OF FORECAST DEMANDS



MARCH 1989

# POTENTIAL RESOURCES

As the period of energy surplus experienced in the 1980's comes to an end, B. C. Hydro will require additional energy to meet projected load growth. Exhibit 4-1 illustrates the magnitude of the gap between existing resources, as outlined in Section 2.3 and Appendix II of this report, and the range of forecast demands described in Section 3.1. The following alternatives appear to be the most economic available to serve the incremental demands. They include improvements to the efficiency of the existing production and utilization systems as well as new facilities.

The short-term emphasis will be on producing and using energy as efficiently as possible, i.e. B. C. Hydro will become, and will encourage its customers to become, "Power Smart". New generation projects will be undertaken when all other available and cheaper options have been exhausted.

## 4.1 POWER SMART PROGRAMS

An important component of B. C. Hydro's Power Smart effort is the customer-oriented programs directed towards reducing future load growth by encouraging more efficient use of energy. This type of program benefits both the customer (through lower electricity bills) and B. C. Hydro (by postponing the need for new generation facilities, thus lowering financial commitments and delaying environmental impacts).

The foundation of Power Smart was developed during the late 1970's and early 1980's through B. C. Hydro's energy management studies and customer advisory service on using energy more efficiently. Power Smart was formally introduced in 1988 and eventually launched in March 1989, through a public awareness advertising campaign.

There are currently twenty-three Power Smart initiatives under development, with the majority starting in 1989 and 1990. The **Residential programs** fall into three broad categories: encouraging fuel substitution, improving the energy efficiency of the building envelope or exterior shell, and encouraging purchase and use of more efficient lighting and appliances. These programs will use promotion and incentives to stimulate participation. The **Commercial programs** will address both the building envelope and major energy uses such as lighting, heating and air conditioning. They will rely on audits for existing buildings and design assistance for new structures. The **Industrial programs** will target improvement of the building envelope and will also promote purchase and use of high efficiency motors, variable speed drives for fans and pumps, energy efficient compressors, plus higher efficiency industrial and street lighting.

Power Smart programs contribute to the efficient allocation of resources by offering opportunities to realize returns on investment comparable to those in supply measures. Programs will be initiated where their total unit cost (including customer costs) is less than that of the alternatives, including new generation. Current information suggests Power Smart program costs (including incentives) to average 1.8¢/kWh for residential programs, 1.9¢/kWh for commercial programs and 1.6¢/kWh for industrial initiatives. Power Smart programs are also expected to provide employment- related benefits. Although no quantitative results are available, studies for both B. C. and the U.S.A. suggest higher overall employment levels for Power Smart programs than from an equivalent level of investment in new generation. Exhibit 4-2 summarizes currently projected costs and energy savings for Power Smart programs by sector.

Programs offered may change as circumstances evolve and as new, more energy-efficient technologies emerge. Power Smart's current goal is for annual energy savings in the order of 2400 GWh by the year 2000. These savings would be over and above the "natural conservation" brought about by voluntary actions of the customers, the impact of which is already accounted for in B. C. Hydro's demand forecasts (Section 3.1). B. C. Hydro will invest in cost-effective programs as they become available, since the technical potential could be as high as 8000 GWh/year.

In addition to these B. C. Hydro-sponsored programs, it is expected that opportunities for further savings will arise through involvement by the private sector. To this end, a public request for proposals of load displacement was issued as part of the request for energy from independent power producers. (An RFP for projects over 5 MW was released in December 1988). This is discussed further in Section 4.4 ("Independent Power Producers").

Appendix IV provides a brief summary of each of B. C. Hydro's Power Smart programs. In addition, Exhibit II-4 contains a projection of the generation savings that would be achieved by the introduction of the programs.

## 4.2 IMPROVEMENTS TO EXISTING FACILITIES

### RESOURCE SMART

Resource Smart is B. C. Hydro's name for a program intended to make existing facilities more efficient and thus obtain significant additional energy from the B. C. Hydro system. This would allow postponement of new generation projects.

Additional energy may be obtained from existing plants by various means, such as replacing turbines with more efficient ones; increasing the frequency of trashrack cleaning; raising the normal operating levels of reservoirs or operating them closer to their normal maximum levels; diverting additional water to a plant from an adjacent drainage basin; installing additional generating capacity to utilize available water; or redeveloping an existing plant with new facilities incorporating some or all of the above features.

A preliminary inventory study completed in 1988 identified approximately 5150 GWh/year of potential additional energy from existing plants, of which some 300 GWh/year will have already been developed by the end of 1989. (This includes for example raising the reservoir level at Seven Mile and undertaking tailrace improvements at Revelstoke). A further 3800 GWh/year shows promise of being economically attractive and environmentally acceptable. The following projects are included under Resource Smart:

| | Average Energy Capability (GWh/year) |
|---|---|
| Keenleyside (1) | 1140 |
| Brilliant Expansion (2) | 580 |
| Waneta Expansion (2) | 950 |
| Seven Mile unit 4 | 290 |
| Small Projects (3) | 840 |
| TOTAL | 3800 |

(1) Generation units would be installed at the Hugh Keenleyside Dam, which was originally constructed as a storage project to provide flow regulation under terms of the Columbia River treaty.

(2) These capacity additions would use water in excess of flows authorized by water licences held by Cominco Ltd., which owns the plants.

(3) Includes Barnes Creek, Duncan, Falls River and other small projects.

An allowance of 2000 GWh/yr has been made in the 1989 Resource Plan for Resource Smart projects, including the Keenleyside project which is individually identified (see Recommended Plan in Section 5.1). Appendix V contains detailed information on some of the more attractive of these projects. Studies currently underway will provide better definition of this resource.

Addition of Units 5 and 6 at either of the Revelstoke and Mica dams is not included in this Resource Plan, since they would not contribute any significant additional firm energy to the integrated system. However, their need is being reviewed given the increasing role of interutility transactions and private power producers, and they may be scheduled for operation in future resource plans.

### DISTRIBUTION

Efficiency improvements can be achieved through reduction of distribution losses by installing larger conductors and by implementing some voltage reduction techniques. The economic attractiveness of these measures is currently being investigated. No allowance has been made in this Plan for potential savings, pending completion of these studies, although U.S. Northwest studies suggest potential economic energy savings in the order of 600 GWh/year for today's B. C. Hydro system.

## 4.3 COORDINATION AND PURCHASES

A number of possible coordination and purchase agreements with neighbouring utilities and a large industrial firm offer a potentially attractive combination of flexibility and fairly priced energy to B. C. Hydro.

### (a) Alberta Interconnected System

The B. C. Hydro system and the Alberta Interconnected System differ significantly in their generation mix. B. C. Hydro's generation system is predominantly hydro-based and therefore inherently rich in peak generating capacity with varying amounts of secondary energy also available in most water conditions. Alberta's system (largely thermal) can offer substantial amounts of energy during hours of low (off-peak) demand. The potential benefits of this diversity through coordinated operation, planning and export are under active study.

Based on the knowledge gained from these studies, it has been assumed that off-peak energy would be available to B. C. Hydro at a competitive price, thereby deferring the need for new generation. B. C. Hydro has assumed that between 1000 and 2000 GWh/year of off-peak, coal-fired energy could be available from Alberta. Similarly, 1000 to 2000 GWh/year of off-peak, natural gas-fired energy would be available, but at a much higher price. Since Alberta may in the long term develop alternative uses for some of this energy, it is assumed that after about eight years no set minimum amount of energy would be available as required, but the combined maximum of 4000 GWh/year **may** still be available.

These assumptions are considered interim measures, to be firmed up contractually within the next one to two years. It is estimated that B. C. Hydro and Alberta utilities could lower their generation costs by anywhere from $600 million to $1.2 billion, over twenty years by coordinating their operations.

### (b) Bonneville Power Administration

Coordination with BPA would make it possible to use B. C. Hydro's reservoir storage at Mica and Williston more effectively.

Current negotiations with BPA are focused on reaching a limited coordination agreement for the operation of American and Canadian reservoir storage on the Columbia River in 1989. The 1989 Resource Plan includes a 1000 GWh firm energy increase attributable to this type of coordination. BPA and B. C. Hydro have agreed to study alternatives for future coordination when this agreement is in place.

### (c) Alcan

Alcan is proceeding with engineering to expand their Kemano generating station by 1995, ahead of Alcan's requirements for industrial purposes. This work is based on an understanding reached in July 1988 between Alcan and B. C. Hydro, whereby both corporations acknowledged principles for Coordination, Power Exchange and Longer-Term Power Sales Agreements. Negotiations are proceeding to finalize these agreements, including prices.

It is expected the agreements will provide B. C. Hydro with 2500 GWh/year of firm energy for a period of twenty years. In addition, coordinated operation of Alcan and B. C. Hydro reservoirs is expected to yield a net gain of 260 GWh/year (firm) to B. C. Hydro.

### (d) Other

Purchases from other sources appear to be less likely. Since both BPA and B. C. Hydro are predominantly hydro utilities and adverse water conditions could affect them simultaneously, it is not likely that surpluses would be available for purchase from BPA. However, utilities further down the Pacific Coast operate oil, gas and coal-fired generation. In an emergency, it is possible that up to 4000 GWh/year of expensive electric energy could be purchased from U.S. utilities.

## 4.4 INDEPENDENT POWER PRODUCERS

### PURCHASE POLICY

B. C. Hydro will be relying on independent power producers and increased self-generation as one of the options to minimize the cost of electric service. Cost-effective independent power production can contribute a portion of B. C. Hydro's supply requirements and allow Hydro to defer more costly projects on the integrated system, and also to reduce financial losses in non-integrated communities.

Independent power production, in B. C. Hydro's context, is defined as electricity generation from an independent or privately-owned facility, which can be connected to the B. C. Hydro system for the purpose of selling electricity. It also covers self-generation (including cogeneration or co-production of steam and electricity). Sales can be made to B. C. Hydro through connections at the 60 kV to 500 kV transmission voltage levels, or 12 kV and 25 kV distribution voltage levels.

Purchases can be made from an independent power producer under one of the following categories:

1. Directly from Independent Power Producers.
2. Surplus electricity from self-generation, including cogeneration.
3. Load displacement by self-generation including cogeneration.
4. Load displacement from energy efficiency measures.

According to a purchase policy developed during 1988, B. C. Hydro will purchase electricity for the integrated system provided that the quality is acceptable and the cost to Hydro is lower than the cost of other alternatives available, including any costs associated with modifying Hydro's facilities in order to accept these deliveries of electricity. The intent is to negotiate a price that provides the lowest cost to Hydro ratepayers, yet reflects the costs of firm and secondary energy.

Factors affecting the negotiated purchase price are reliability and duration of supply, impact on the existing system and dependability of deliveries. Financing arrangements to help make projects feasible will be considered, although preference will be given to those entailing a lower degree of financial risk to B. C. Hydro.

Requests for proposals (RFP's) were issued in November 1988 for the supply of electricity to Fort Nelson, and in December 1988 to supply up to 150 MW for the B. C. Hydro integrated system from projects of 5 MW or greater. A separate RFP for up to 25 MW from projects of less than 5 MW is being issued as this report is completed. Other RFP's will be issued as new generation is required.

Considerable interest has been expressed in this power purchase policy, but the generation potential from cost effective projects is unknown at this time. Projects which were previously examined by B. C. Hydro are among those available for private development, although the provincial government, in reviewing recently B. C. Hydro's jurisdiction, has concluded that projects on the Peace and Columbia rivers will be developed and operated by B. C. Hydro, since large public investments have already been made on these rivers. (B. C. Hydro will, however, consider proposals that could lead to lower costs to ratepayers as a result of taxation or other innovative design and financing arrangements that may be available to the private sector.)

Thirty-five notifications of intent to submit proposals for domestic supply, for a total of 1795 MW were received in response to the December 1988 RFP. Pending further analysis of these proposals, an allowance has been made in this Resource Plan for annual purchases of 1000 GWh from independent power producers, beginning in 1994.

A brief description of Hydro's purchase policy, the RFP process, purchase price guidelines and general technical requirements can be found in Appendix VI.

### LOAD DISPLACEMENT

Both increased generation by a B. C. Hydro customer (generally referred to as "self-generation"), and the more efficient use of electricity by a customer reduce the demands served by B. C. Hydro and thus "release" some electricity that now becomes available to other B. C. Hydro customers. This is commonly known as "load displacement", and has the same effect on Hydro's integrated system as increasing the supply of energy by constructing new generation projects.

Self-generation can include cogeneration; if the customer generates electricity in excess of its own requirements, the surplus may be available for sale to B. C. Hydro. More efficient use of electricity is achieved through introduction of currently available energy-efficient equipment, such as electric motors, lighting systems or even higher levels of insulation, all of which can provide the same service while consuming less electricity.

B. C. Hydro believes that there are many opportunities for load displacement where electricity could be made available at a potentially lower cost to B. C. Hydro ratepayers than from new generation. Therefore, B. C. Hydro is interested in encouraging commercial and industrial customers that can implement this more efficient use of energy.

Concurrent with its RFP program for electricity purchases from projects greater than 5 MW, B. C. Hydro has included load displacement projects which effectively can be considered as competing with the generation projects. The intent is to negotiate a price that provides the lowest cost to B. C. Hydro ratepayers yet reflects the price of firm energy. B. C. Hydro is looking to the project sponsors to develop a reliable and workable monitoring system for measuring the actual load displacement.

### COGENERATION

Cogeneration may provide an opportunity for cost-effective power purchases. Most of the existing cogeneration in B. C. is in the forest industry. The B. C. pulp and paper industry presently has more than 470 MW of cogeneration installed. There is also approximately 75 MW of cogeneration installed by the wood products industry and a small quantity by the food and beverage industry, oil and gas industry and hospitals. B. C. Hydro is encouraging energy efficiency through cogeneration and will consider purchasing electricity from cogenerators, or assisting them to reduce their future demands on B. C. Hydro.

Currently, B. C. Hydro's planning studies assume an additional potential of up to 1400 GWh/year from cogeneration. Approximately 700 MW of incremental cogeneration has been identified, but the economics of most of the projects comprising this total is uncertain. Based on a twenty-five-year plant life it is expected that many of these projects could produce energy at less than B. C. Hydro's long-term marginal cost (see Appendix VIII). However, many would be rejected as uneconomic if a short payback period was a criterion, as private industry often requires. Although the ultimate potential for independent power producers in general, and cogeneration in particular, is unknown, it should become better defined once the initial proposal call for 150 MW is reviewed.

### ALTERNATIVE ENERGY

Alternative energy sources, such as small hydro, biomass (wood waste) and wind resources, offer potential for remote communities currently being served by diesel generation. An agreement was reached in 1988 with the Queen Charlotte Islands Power Corporation for supply from a small hydro project on Moresby Island. B. C. Hydro also cosponsored a two-day seminar in February 1989 on "Energy from Municipal Solid Waste", which examined B. C. Hydro and the private sector's role in electricity generation from municipal solid wastes.

## 4.5 DOWNSTREAM BENEFITS ARISING FROM COLUMBIA RIVER TREATY

The Canadian entitlement to downstream power and energy benefits resulting from the operation of storage at the Duncan, Keenleyside and Mica Projects under the Columbia River Treaty was sold to the United States for a period of thirty years from the commencement of operation of each project. Thus, these power benefits will revert to British Columbia gradually, beginning in 1998/99.

The magnitude of the annual downstream benefits after 1998/99 depends upon several factors. It is most sensitive to the rate of electric load growth in the Northwestern United States and to the amount of thermal and hydroelectric resources used to serve this load growth. A high electric load growth in the United States served by thermal additions has the effect of reducing the Canadian entitlement at a faster rate than either low growth rates or use of other resources to serve new growth. The downstream benefit estimates shown in Appendix II are based on a 1986 BPA forecast, although no significant changes are expected.

In addition to energy, the downstream benefits have a substantial peak component. Both the capacity and energy benefits are expected to decline with time as the U.S. system grows.

The downstream benefits belong to B. C. according to the Canada - B. C. agreement dated 8 July 1963, and could provide a very valuable resource to the province in the early 2000's.

## 4.6 NEW GENERATION PROJECTS

As indicated in Section 3, the annual demand for electricity in the B. C. Hydro Integrated System is expected to grow from roughly 42 300 GWh in 1988 to 72 000 GWh twenty years later, in 2008, according to the probable forecast. While demand-side management, coordination agreements, purchases, and additional energy from existing plants are expected to make a significant contribution to meeting the new demands, construction of new generation facilities will likely be required for service by the late 1990's.

It may take ten to twenty years to plan, design, license and build a major generation project. Typically, some five to eight years are needed for engineering and environmental studies to determine the feasibility of a project and then to design it, including assessment of its environmental impacts, in enough detail for an Energy Project Certificate application. The regulatory review process may require from one to three years, depending upon the size and complexity of the project. Project construction, which commences after all regulatory approvals are in place, may require approximately six to nine years. Even on the Peace Site C and Keenleyside projects, for which licensing is well advanced, a further eight years could be required to completion.

Some energy intensive projects such as modern pulp mills (CTMP) have lead times of less than two years. This creates a situation where demand response is much faster than the supply response, which exacerbates the supply planning problem.

For this Plan, it was considered that the following projects could be available to meet future domestic demands.

| | Average Energy Capability (GWh) | Earliest Feasible In-Service Date |
|---|---|---|
| **Hydroelectric** | | |
| Peace Site C | 4 710 | 1997 |
| Murphy Creek | 1 450 | 1999 |
| Stikine — Iskut | 15 600 | 2004 |
| Liard | 18 400 | 2009 |
| Resource Smart | 3 800 | variable |
| **Thermal** | | |
| Hat Creek | 13 140 (firm) | 1999 |

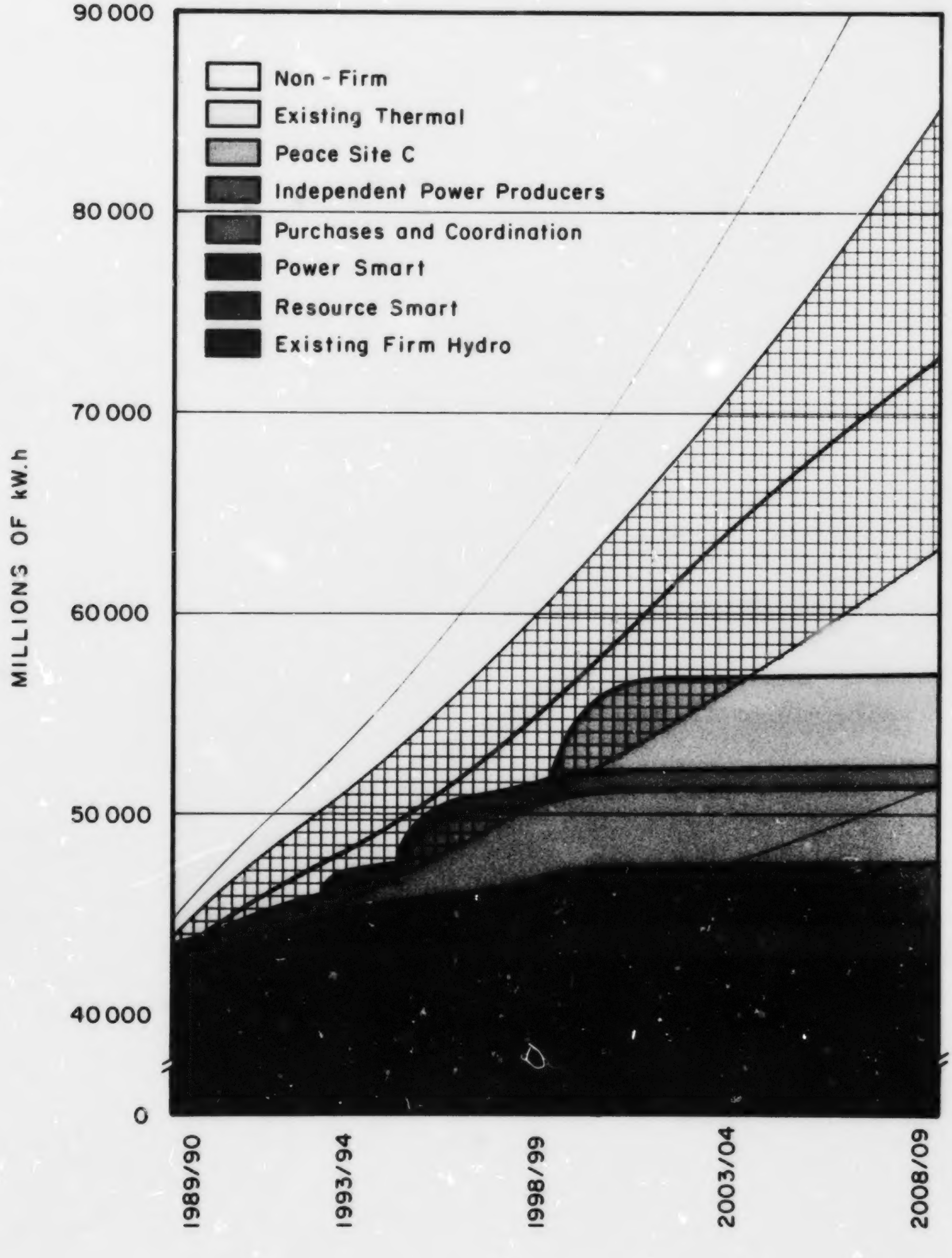
The Keenleyside project (included in Resource Smart) and the Peace Site C project are the most economic new energy resources available within developed river basins, and have been the subjects of detailed investigations. The Murphy Creek project on the Columbia River has also been studied in detail. The degree of engineering and environmental information available for other potential projects varies considerably, and further studies would be required before any could be considered for licensing.

The private sector will play an increasing role in the future in this regard. In October 1988, Klohn-Crippen Consultants Limited became the prime consultant to B. C. Hydro for hydroelectric work, and were awarded a $7 million contract to complete unfinished studies and investigations for the Peace Site C and Keenleyside projects.

The relative energy costs and expected annual energy contribution of the Power Smart and Resource Smart programs, cogeneration, coordination and purchase agreements, selected hydroelectric projects and the Hat Creek thermal project are shown in Exhibit 4-3. A map showing the approximate location of these projects is also provided (Exhibit 4-4). Capsule descriptions of potential projects, with preliminary estimates of capacity, energy capability, earliest in-service date and approximate cost, are contained in Appendix V. Also included in Appendix V is a summary of surveys and investigations of potential generation projects which will continue or be undertaken in 1989/90. These studies will enable B. C. Hydro to maintain an inventory of resource options for possible future development.

EXHIBIT 4-1

# EXISTING AND PLANNED RESOURCES vs RANGE OF FORECAST DEMANDS



MARCH 1989

EXHIBIT 4-2

# *POWER SMART PROGRAMS IMPACT AND ECONOMICS*

| Sector | Projected BC Hydro Expenditure * 20 Year Total ($millions) | Projected Energy Savings YEAR 2000 (GWH) | Projected Energy Savings 20 Year Total (GWH) | Total Unit Cost ** (¢/kWh) |
|---|---|---|---|---|
| RESIDENTIAL | 58.0 | 500 | 8,400 | 1.8 |
| COMMERCIAL | 94.1 | 800 | 12,300 | 1.9 |
| INDUSTRIAL | 72.9 | 1,100 | 14,700 | 1.6 |
| TOTAL | 225.0 | 2,400 | 35,400 | |

* Projected B.C. Hydro expenditures include all B.C. Hydro program costs plus incentives.

** Total unit cost: based on applying a 6% discount rate to the total (B.C. Hydro and customer) costs and energy savings over the 20 year period.

EXHIBIT 4-3

## RESOURCE OPTIONS

## UNIT ENERGY COSTS AND FIRM ENERGY CAPABILITIES

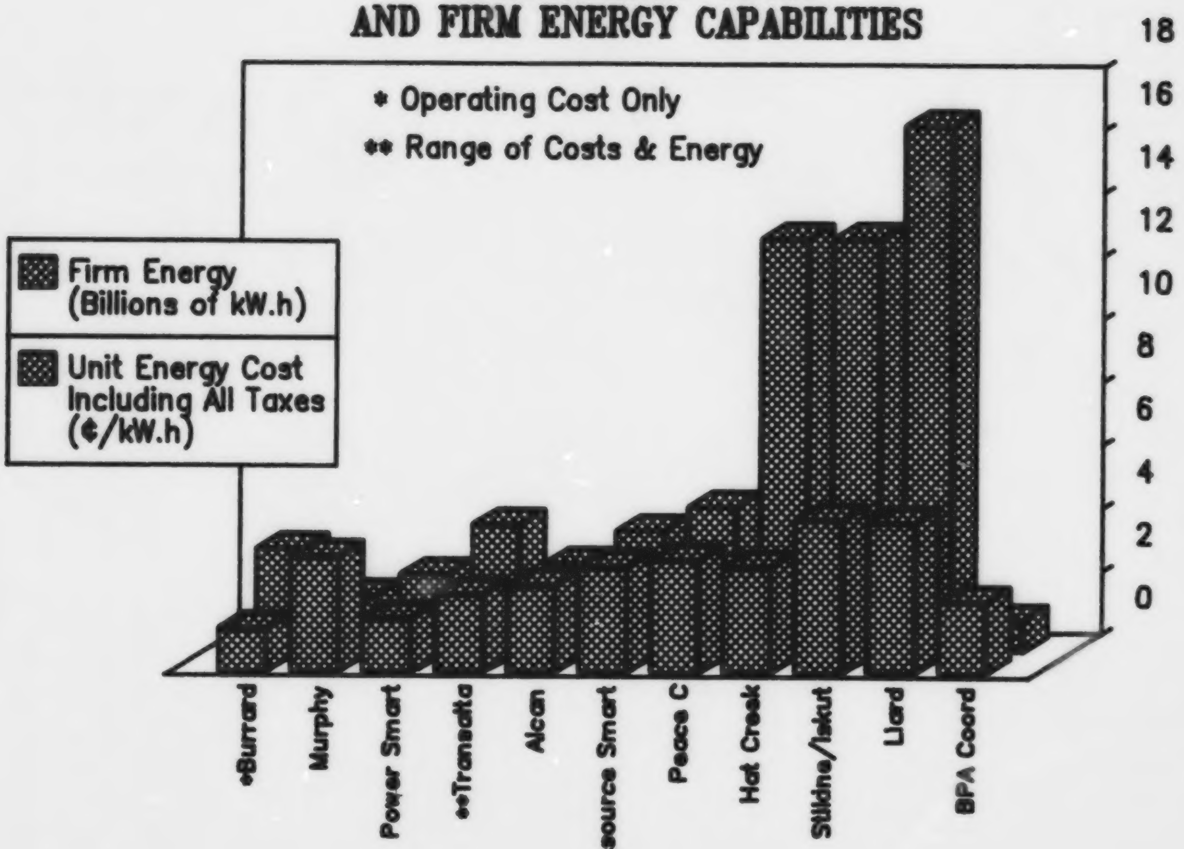
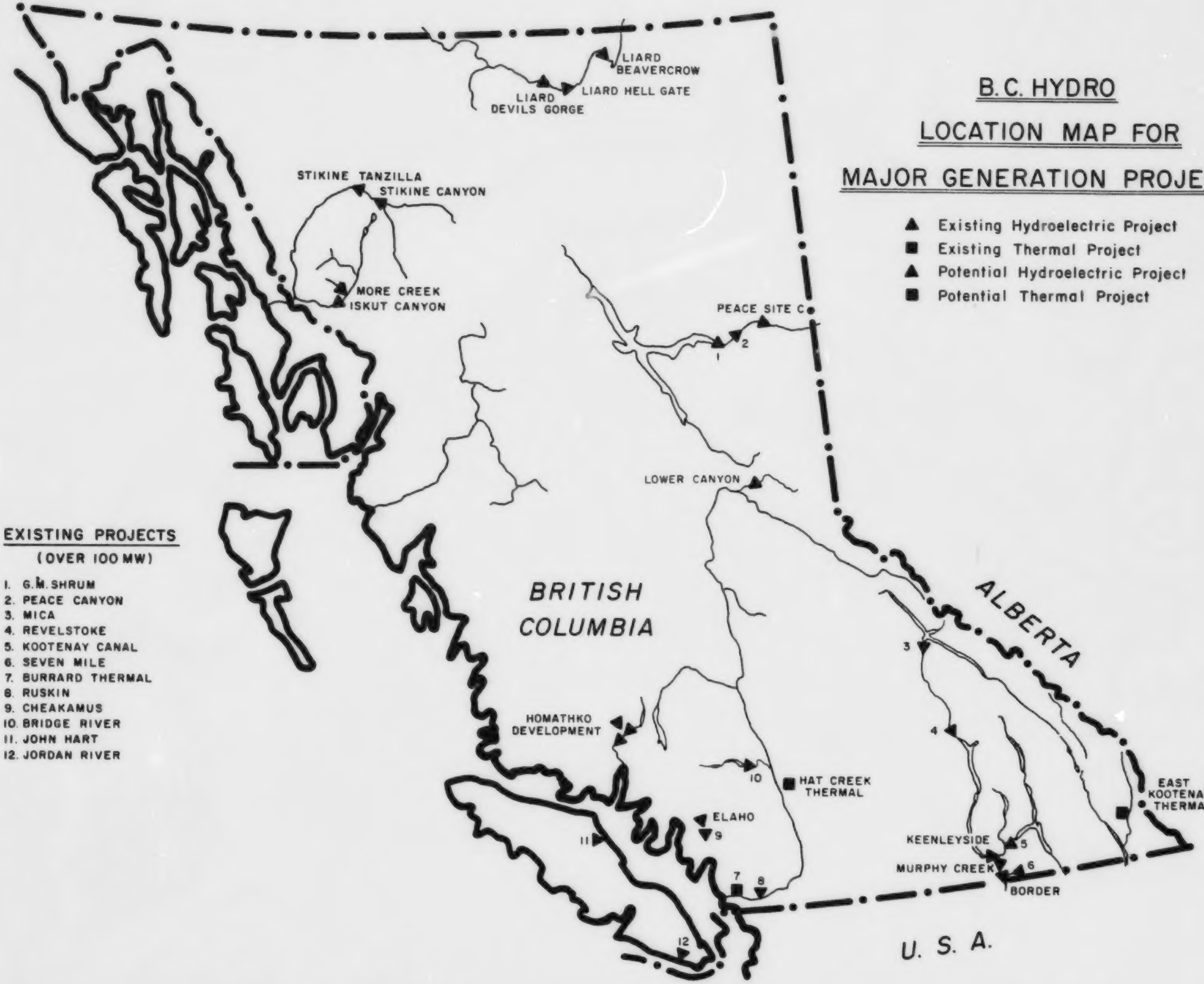


EXHIBIT 4-4

## B.C. HYDRO

## LOCATION MAP FOR MAJOR GENERATION PROJECTS


▲ Existing Hydroelectric Project
■ Existing Thermal Project
▲ Potential Hydroelectric Project
■ Potential Thermal Project
LIARD BEAVERCROW
LIARD HELL GATE
LIARD DEVILS GORGE
STIKINE TANZILLA
STIKINE CANYON
MORE CREEK
ISKUT CANYON
PEACE SITE C
1
2
LOWER CANYON
BRITISH COLUMBIA
ALBERTA
3
4
HOMATHKO DEVELOPMENT
10
HAT CREEK THERMAL
ELAHO
9
11
7
8
12
EAST KOOTENAY THERMAL
KEENLEYSIDE
5
MURPHY CREEK
6
BORDER
U. S. A.

**EXISTING PROJECTS**

(OVER 100 MW)

1. G.M. SHRUM
2. PEACE CANYON
3. MICA
4. REVELSTOKE
5. KOOTENAY CANAL
6. SEVEN MILE
7. BURRARD THERMAL
8. RUSKIN
9. CHEAKAMUS
10. BRIDGE RIVER
11. JOHN HART
12. JORDAN RIVER

# TWENTY-YEAR RESOURCE PLAN

## 5.1 RECOMMENDED PLAN

The foregoing sections on B. C. Hydro's existing resource base, demand forecasts, marketing programs and potential resources point to the uncertainty inherent in both supply and demand. The selection of a Resource Plan requires determining the combination of resources which minimizes total long-term costs while meeting prescribed service standards; but it also requires proper balancing of risks arising from investing in new resources unnecessarily, or too early, against those from building too late, thus causing an unreliable supply of electricity and constraining economic development. In addition, the selected plan must be flexible enough that it can be modified to respond to potentially different outcomes.

B. C. Hydro's recommended Resource Plan to 2000 relies on a combination of coordination and purchase agreements with other energy producers, Power Smart programs, efficiency improvements to existing B. C. Hydro facilities, and new generating capacity. The Plan is summarized below, and also shown graphically in Exhibit 5-1, to indicate how the approximate contributions of all resources would stack up against the range of potential forecast outcomes.

The selection of additional resources to the system after the year 2000 has not been made, as B. C. Hydro will be undertaking during 1989 a comprehensive analysis of the options available, and seeking public input to this effect. Section 5.3 outlines the main attributes of three alternative resource scenarios and their perceived strengths and weaknesses.

**Recommended Plan**

| | |
|---|---|
| Power Smart Programs | Ongoing |
| Resource Smart | Ongoing |
| TransAlta Coordination/Purchase | Under Discussion |
| BPA Coordination | 1989 |
| Purchases from Independent Power Producers | 1994 |
| Alcan Coordination and Energy Purchase | 1995 |
| Keenleyside — Murphy<br>(Murphy Creek in-service later) | 1998 |
| Peace Site C | 1999 |
| Additional resources (e.g. Downstream Benefits) | Post - 2000 |

The timing of Keenleyside, Peace Site C and the next resource additions will depend on demand growth, the outcome of negotiations with TransAlta, the return or sale of the Columbia River downstream benefits, and the contribution made by independent power producers.

Studies are being carried out in 1989 to enable B. C. Hydro to apply for licenses for Keenleyside and Site C as early as 1990, if necessary. An extended application involving both the Keenleyside and Murphy Creek projects will be required, given their close interrelationship. The timing of Murphy Creek has yet to be determined.

The Plan to 2000 requires expenditures on fixed assets (including transmission, stations and communications) in the order of $100 million annually until 1992, and then rapidly increasing to about $600 million per year by 1997, in 1988 dollars. Total project expenditures over the ten-year period (including overheads and interest during construction but excluding inflation) would approach $4 billion.

## 5.2 TRANSMISSION REQUIREMENTS

This section outlines the major transmission additions that are planned to the end of this century as shown in Exhibit 5-2. Planned expenditures on transmission, stations and communications over the ten-year period to 2000 average in the order of $100 million annually, in 1988 dollars. It should be noted that some of these lines and their timing are dependent on some specific generation projects going ahead. More detailed information on these projects can be found in Appendix VII.

- American Creek Series Capacitor Station (1990): This station is being built north of Hope to increase the capability of the 500 kV transmission lines bringing power into the Lower Mainland.
- Puget Sound Power & Light Transmission Intertie (1992): An intertie consisting of a switching station and two 230 kV transmission lines is planned to provide for direct power sales to Puget Sound Power and Light. The proposed transmission crossing point at the international boundary is south of the Aldergrove/Abbotsford area.
- Static VAR Compensator Installations (1993, 1997 and 1999): They are planned for installation at Malaspina Substation on the Sechelt Peninsula, Kelly Lake Substation near Clinton and Nicola Substation near Merritt respectively. Static VAR compensators are electrical devices used to enable the transmission system to transfer more power.
- Kitimat-Skeena Transmission Line (1994): Alcan is planning the completion of its expanded generation facilities at Kemano by 1 January 1995. B. C. Hydro's purchase of power from Alcan will require a second 287 kV transmission line between Kitimat Substation and Skeena Substation near Terrace.
- Williston-Kelly Lake Transmission Line (1994): In addition to the Kitimat-Skeena line, B. C. Hydro's purchase of power from Alcan's Kemano Completion Project will require that a third 500 kV transmission line be built between Williston Substation near Prince George and Kelly Lake Substation near Clinton, to bring the additional Kemano power south to the Lower Mainland and Vancouver Island.
- Kelly Lake-Cheekye Transmission Line (1995): Because of continuing load growth in the Lower Mainland and on Vancouver Island, a second 500 kV line is planned between Kelly Lake Substation near Clinton and Cheekye Substation near Squamish.
- Washington Water Power Transmission Intertie (1995): An intertie consisting of two 230 kV transmission lines from Selkirk Substation near Trail is planned to provide for direct power sales to Washington Water Power. The proposed transmission crossing point at the international boundary is south of Selkirk Substation.
- Nicola-Meridian Transmission Line (1998): A second 500 kV transmission line is planned near the end of this century between Nicola Substation near Merritt and Meridian Substation north of Coquitlam in response to forecasts of increasing load demand in

the Lower Mainland and on Vancouver Island.

- Keenleyside-Selkirk Transmission Line (1998): A single 230 kV transmission line from Keenleyside to Selkirk Substation will be required to connect the Keenleyside generating station to the B. C. Hydro provincial electrical grid.
- Site C-Peace Canyon Transmission Lines (1999-2000): Two 500 kV transmission lines from Site C to Peace Canyon will be required to connect Site C to the B. C. Hydro provincial electrical grid. The first line is scheduled to be completed at the same time as Site C generation and the second line a year later.

## 5.3 RESOURCE SCENARIOS BEYOND 2000

Additional resources to those listed in Section 5.1 will be required after 2000 according to this Plan. Although obviously demand growth, the relative success of initiatives such as Power Smart, and the response of the private sector will impact on such timing, planning how to meet demands after the turn of the century must be done long in advance. This section examines in general terms the main attributes of three resource scenarios, which although **not mutually exclusive,** reflect a primary reliance on a given option: hydroelectric, thermal, or a combination of supply and demand management.

### 5.3.1 HYDROELECTRIC OPTION

British Columbia is fortunate to have hydroelectric resources available for development well into the next century. So far only a quarter (about 10 000 MW) of the province's total hydro potential has been developed. A further 10 000 MW appears to be developable. The remainder involves hydroelectric sites which are not in B. C. Hydro's current planning inventory, due to either environmental or economic constraints.

Traditional merits of hydroelectric generation are:

- Mature technology with a proven track record which provides low outage rates and high reliability.
- Renewable, inflation-free fuel (falling water supplied by rain and snow).
- Potential plant life of seventy years or more, with very low operating costs, minimum manpower requirements and automated operation.
- No environmental problems relating to air and water pollution, toxic wastes, and fuel transportation hazards.
- Ability to "store" electricity temporarily in the form of retained water, and to respond rapidly to changes in demand.

On the other hand, there are several drawbacks that have altered and slowed down the course of hydropower development and have created some uncertainty about its future:

- Requirement for preservation of the natural environment: Growing concern during the past decade resulted in the development of a rigorous environmental study and review process as part of project licensing. Fish, wildlife, natural, scenic and cultural features as well as opportunities for recreation must be addressed.

- Energy economics: Hydropower costs are very sensitive to fluctuating interest rates, given their high capital costs. An increase in the discount rate from 6% to 8% can add over 30% to their costs.
- Long lead times: Significant time elapses between commencement of studies and commissioning of a project. Larger hydro projects are less flexible to adjust to changing economic conditions and would have to be justified on the basis of securing a long-term source of low cost energy.

B. C. Hydro has already studied, in varying levels of detail, many of the potential projects, and those have been included in the proposed hydroelectric development scenario outlined below. Other smaller projects may also be identified and developed by B. C. Hydro or the private sector.

The proposed hydroelectric development scenario beyond the year 2000 groups potential projects into three categories:

1. **Lower Columbia River Projects:** Fourth unit at Seven Mile, Brilliant Expansion, Waneta Expansion, Duncan Power Plant, Murphy Creek, and Border.

   These projects constitute the final stage of the "Two River Policy" that was initiated by the Province in the early 1960's. They would provide close to 1300 MW of additional capacity and would meet about two to three years of load growth. Studies currently underway will help define the most desirable configuration and development sequence. Their estimated costs range from 2.3¢/kWh to 4.4¢/kWh.

2. **Undeveloped River Basins of Southern and Central B. C.:** Elaho, McGregor River Lower Canyon, and Homathko.

   This second group consists of moderately sized hydroelectric resources in undeveloped river basins that would be relatively close to the existing transmission grid, or to major population centres. These projects would provide about 1600 MW of additional capacity and could meet about five years of load growth. Estimated costs are in the order of 5.5¢/kWh.

3. **Northern Rivers:** Stikine/Iskut, and Liard.

   These projects would be the cornerstone of any plan for continued reliance on hydroelectric resources in British Columbia. In the early 21st century the northern river projects would play a similar role to the one played during the past several decades by the Peace and Columbia river developments. The Liard and Stikine could provide about 6000 MW of new hydro-electric power supporting between fifteen and twenty years of load growth. They are also potentially attractive: about 5 to 5.4¢/kWh including transmission. However, because of their remoteness, size, capital requirements, environmental and social impacts, as well as international and interprovincial implications, their development presents major challenges.

   Numerous problems have been identified in connection with the Stikine/Iskut projects, regarding salmon spawning, loss of wildlife habitat, and partial loss of scenic qualities, but with due care they might be developed for the benefit of British Columbians. Northwest B. C. has substantial mineral deposits and scenic qualities that could open up opportunities for tourism, but lacks virtually all the necessary infrastructure to sustain development of these resources.

The Liard project is the least flexible and most capital intensive, but would eventually have to be harnessed if the hydroelectric option is chosen for the Province. In its initial years of operation, the Liard development would provide substantial surpluses of energy to domestic needs. To improve its economic feasibility, this project would have to be planned together with a long-term economic development plan for the Province, including temporary electricity exports to the U.S. or development of energy-intensive industries. B. C. Hydro realizes that adoption of a future hydroelectric development strategy will have to take into account the interests of all the people of the Province as well as people of Alaska, the Yukon and the Northwest Territories. A public consultation program would be undertaken at the outset of the planning studies to ensure that local interests and concerns are addressed. Although cost-effectiveness will remain an important consideration, concerns for the environment and people affected by potential developments will play a major role in the selection of a preferred electricity development strategy for British Columbia.

Exhibit 5-3 provides an idea of how hydroelectric resources could be developed to meet currently forecast demands beyond the year 2000.

### 5.3.2 THERMAL OPTION

The selection of thermal generation alternatives is based on the advantages and disadvantages of fuel sources and technologies. The **fuel sources** include coal or gasified coal from Hat Creek, East Kootenay, Northeast B. C., Telkwa, Klappan or Vancouver Island; natural gas from northeast B. C.; refinery by-product gas from Vancouver, Taylor and Prince George; hog fuel from Williams Lake, Quesnel, Prince George and Mackenzie; black liquor from pulp mill sites throughout the province; municipal solid waste (MSW) from Victoria and Vancouver; and uranium from unspecified sites in the B. C. Interior.

Several **technologies** are available. Coal can be used in a conventional pulverized fired (PCF), atmospheric fluidized bed (AFBC), or a pressurized fluidized bed (PFBC) boiler. Coal can be gasified and used in a gas turbine or gas turbine combined cycle (gas turbine cycle plus steam cycle) system. Natural gas can be used in gas turbine or gas turbine combined cycle systems and in conventional gas-fired thermal plants. Hog fuel boilers can use pile burning, AFBC or pulverized firing technologies. MSW can be either converted to refuse-derived fuel or mass-burned.

#### ADVANTAGES AND DISADVANTAGES

Thermal power generation offers a flexible method of meeting future demands at costs competitive with those of large hydro developments. Among its advantages are schedules that can be altered by delaying units if there is a reduction in load growth; often shorter lead times; less land alienation relative to the energy generated; generally lower capital requirements; long-term employment; less disturbance of watercourses; generation which is assured irrespective of water conditions; and siting flexibility, which may allow for closer proximity to demand centres.

As with any large industrial complex, there are environmental and other impacts from thermal power generation. Air emissions are the greatest concern, particularly with large coal-fired plants, and at the present time, a major concern is the "greenhouse effect", which in the U.S. has revived calls for renewal of the nuclear program.

A summary of thermal power generation alternatives is provided below.

- Municipal Solid Waste: The unit energy cost is in the order of 6¢/kWh assuming a tipping fee of $44/t of municipal solid waste. MSW reduces disposal by landfill and uncontrolled incineration, is a renewable resource, and its impacts are localized. On the other hand, it may sometimes contain hazardous substances, and yields a limited amount of electricity at a high cost.
- Wood Waste: Energy costs can range from 1.5 to 4.0¢/kWh and even higher for a cogeneration plant. It offers many of the same advantages as MSW. However, the supply of wood waste is also limited.
- Coal: Energy costs are 3.5 to 5.8¢/kWh, depending on the generation technology and source of coal. Its advantages are largely covered under "thermal generation" above, while the main drawbacks are related to emissions, perception of acid rain problems, and the requirement for large mining operations.
- Coal Waste: Energy costs are comparable to using thermal coal. Its disadvantages are also similar, but it offers some advantages, such as less land alienation, not requiring a mine, and improving the efficiency of coal use.
- Natural Gas: Energy costs range from 3.1 to 4.0¢/kWh assuming gas prices between $1.80/GJ and $2.70/GJ. It offers lower emissions, high efficiency with combined cycle, short lead time, low capital costs, and no mine is required. However, natural gas prices are expected to increase considerably, and its supply could be restricted by the mid-1990's.
- Uranium: The cost of electricity from a CANDU reactor is in the order of 4.0 to 4.4¢/kWh. Advantages are no emissions, no acid rain, and the secure supply of uranium. Disadvantages are well known: high capital costs, long lead times, unresolved waste disposal problems, and the risk of a nuclear accident.

## THERMAL POWER GENERATION SCENARIO

For a thermally-based development scenario, the four fuels selected are, in order of preference: MSW, wood waste, coal and natural gas.

The technologies selected are currently available and where possible, specific projects are identified. However, it is recognized that PFBC may be commercially available around the year 2000, and thus it might be advisable to delay the installation of coal-fired generation with gas turbine-combined cycle generation in order to take advantage of the higher efficiency and versatility offered by PFBC technology.

It is assumed that wood-fired cogeneration plants could be constructed at Williams Lake (39 MW), Quesnel (23 MW), Prince George (47 MW) and Mackenzie (22 MW). Although significantly more electricity could be generated if the wood fuel was used in a thermal plant rather than a cogeneration plant, the overall efficiency would be lower. One impediment to additional wood-fired cogeneration at pulp mills is the short payback period required by forest industry companies.

The cost of private sector, coal-fired thermal power generation using East Kootenay coal rejects and coal waste is similar to the cost of electricity from Hat Creek. Between the reserves of coal refuse in place and the planned production, there should be ample resources for a 600 MW thermal plant. Private sector development would likely ensure coal supply, which would be a concern if B. C. Hydro financed, built and operated the plant.

The largest economic thermal potential in B. C. is the Hat Creek coal deposit. Although the power plant size was set at approximately 2000 MW for this analysis, a 5000 MW plant was given cursory examination in the 1970's and there are sufficient coal reserves for such a plant. It is assumed that the plant would use conventional pulverized firing which is still the most economic technology.

A gas turbine combined cycle plant could be constructed close to the Lower Mainland to provide diversity in generation facilities and reduce transmission requirements. The cost of energy from a 662 MW plant is currently competitive with other forms of generation, but very susceptible to future increases in the cost of natural gas.

A summary of the energy contribution from the different sources of thermal generation is provided in the table below, and also in Exhibit 5-4. Coal and gas-fired units could be added to meet increases in demand.

**Thermal Power Generation Scenario**

| Project | Firm Energy Capability (GWh) |
|---|---|
| Municipal Solid Waste | 380 |
| Wood Waste (Cogeneration) | 920 |
| East Kootenay | 3 940 |
| Hat Creek | 13 400 |
| Gas Turbine Combined Cycle | 4 640 |
| TOTAL | 23 280 |

### 5.3.3 ALTERNATIVE ENERGY OPTION

Sections 5.3.1 and 5.3.2 described resource scenarios based primarily on conventional large-scale hydro and thermal projects. This section presents an alternative resource scenario that is primarily based on small-scale projects and energy efficiency measures that in most cases would probably be best developed by independent private concerns with the energy purchased by B. C. Hydro. The Alternative Energy scenario relies primarily on the following options to balance the demand and supply of electricity after the construction of Keenleyside and Peace Site C:

| Supply Side | Demand Side |
|---|---|
| - Completion of Columbia River Development | - Energy Efficiency (Power Smart II) |
| - Purchased Generation | - Customer Self-generation |
| - Small Hydro | - Marginal Cost Pricing |
| - MSW, Cogeneration | - Fuel Substitution |
|  | - Emerging Technologies |

The selection of options for the Alternative Energy Scenario would result in a package of flexible, relatively small-scale projects, strategies and programs that could be modified as events unfold. In comparison to large-scale conventional project development, the Alternative Energy Scenario would have significantly reduced environmental impacts but would also be subject to the uncertainty of customer responses and choices. The economics of this scenario are also more difficult to define in precise terms at present.

Exhibit 5-5 gives an indication of how demands and supply would be matched in this scenario.

## DEMAND FORECAST, TECHNOLOGICAL PROGRESS AND RELATED ISSUES

Global economic events in the 1970's resulted in major oil price increases which motivated a keen interest in energy efficiency and conservation. Although this interest declined somewhat in the 1980's, development of efficiency measures has continued, and some devices have proven attractive even at today's relatively low energy costs. As the energy surpluses of the early 1980's are consumed by the current, more buoyant economic activity, utilities are faced with having to plan for new resources at a time of great uncertainty.

One of the key variables in the preparation of demand forecasts is the prediction of how B. C. Hydro customers will use electricity in the future, which in turn is heavily dependent on what new technology B. C. Hydro customers incorporate into their lifestyle. Since the rate of change in technology stands at unprecedented levels, it is extremely difficult to predict how energy use will change and at what rate. Recent studies of the impact of emerging technologies on long-term electricity needs suggest that B. C. Hydro forecast demands may be lowered by about 4000 GWh/year over twenty years, primarily in the commercial sector.

As an energy form, electricity is a highly versatile and refined product. If electricity were reserved for those uses for which it is best suited and for which there are no practical alternatives, the consumption of electricity would be reduced and consumption of other fuels would increase. If electricity use for space heating, hot water and cooking were phased out over the next twenty years, B. C. Hydro's forecast demands would be reduced by about 3000 GWh/year.

## RATES AND INVESTMENT CRITERIA

B. C. Hydro rates could also be used as a tool to encourage optimum use of electricity and investment in utility facilities, private generation and conservation equipment. Implementation of such a strategy would benefit from resolution of the difference in investment criteria between the utility and its customers. Although most energy efficient equipment has a useful life of ten to twenty years, most customers want to recover their investment over two to five years, while utilities normally amortize the costs of new facilities over their expected lives. To achieve a balance, the utility could invest in the customers' conservation equipment and own the resulting energy savings much the same as the utility owns its energy production facilities.

Current studies suggest that if rates were set equal to the marginal cost of producing electricity, trailing rate steps would increase 15 to 20% on average, and electricity consumption could decrease by an estimated 6000 to 11 000 GWh/year by the year 2000. Such rate changes would have significant impacts, and would have to be phased in gradually to enable customers to make the necessary investments in energy efficiency and generation.

## RESOURCES

- **Energy Efficiency and Conservation:** As outlined in Section 4.1, B. C. Hydro has initiated a package of energy efficiency and conservation programs as part of the Power Smart strategy. These programs are expected to reduce demands by about 2400 GWh/year by the year 2000. B. C. Hydro could opt for more ambitious conservation targets. Applying the assumptions from plans developed by the Northwest Power Planning Council to B. C. Hydro suggests that demands could be reduced by about 8000 GWh/year within twenty years.

  Rapid advancements are being made in the field of energy efficiency. The best energy saving technologies on the market today did not exist or were not available a year ago. It is now possible to save twice as much electricity as could be saved five years ago, and at half the cost. The technology exists today to save 75% of the electricity presently consumed, and while a large portion of that technology would not be economically competitive today, it is assumed that a significant portion could become attractive over the next twenty years. There are also advantages related to planning flexibility and employment benefits from these programs.

- **Completion of the Columbia River development:** Several projects on the lower Columbia River could be completed without significant added environmental impacts, for a combined potential of about 1900 GWh/ year (installation of a fourth unit at Seven Mile, addition of generation facilities at Duncan Dam, and expansion of Brilliant and Waneta stations). Murphy Creek and Border could also be developed for an addition of about 3000 GWh/year.
- **Small Hydro:** Studies completed in 1984 identified a total small hydro potential of about 5800 GWh/year that could be connected to the B. C. Hydro grid. Although some of this potential could not be developed due to environmental or economic constraints, small hydro can make a significant contribution.
- **Municipal Solid Waste (MSW) and Cogeneration:** These resources are described in

more detail under the thermal option. At present, MSW offers a generation potential of about 380 GWh/year in Vancouver and Victoria. Development of wood waste-fired cogeneration at Prince George, Quesnel, Williams Lake, and Mackenzie would contribute about 900 GWh/year.

### TRANSMISSION

In general the transmission requirements for the Alternative Energy Scenario would be limited compared to those for large-scale conventional hydro or thermal projects. Transmission corridors into and within the Lower Mainland are limited and increasingly difficult to acquire. Maximum use of these corridors can be made through currently available and emerging technical enhancements and innovations. The application of superconductivity in power utility facilities may still be many years away, but the potential benefits could be significant.

### THE ENVIRONMENT

The focus of the Alternative Energy Scenario is directed towards the efficient use of energy, maximizing production from existing facilities, and encouraging the adoption of new and emerging energy efficient technology. Serving existing and future B. C. Hydro customers with such energy will, in general, result in reduced environmental impacts.

Although cogeneration, the burning of nonrecyclable municipal solid wastes and hog fuel-fired generation would release some pollutants and acid rain, many of these fuels are being burned today without generating electricity, and so the addition of generation facilities would not add to the existing environmental impacts. The addition of equipment to reduce and control emissions could improve environmental quality.

Small hydro, the above noted combustion sources and technological advancement, on fuel cells, solar, wind or tidal generation could enable them to meet small localized requirements. Small hydro plants do not affect a large land base and can be situated to avoid many environmentally sensitive areas. A significant benefit of meeting the electricity demand at the source, either through generation or conservation, is that transmission facilities are minimized, thereby avoiding the land use, visual impacts and other environmental impacts inevitably associated with transmission lines.

## 5.4 CONTINGENCY OPTIONS

With the recent launching of Power Smart and the issuing of requests for proposals from the private sector, plus the ongoing nature of discussions with TransAlta, it is too early to ascertain the likelihood of success of each initiative. An ongoing review of these activities during 1989, as well as continuing monitoring of domestic demands for electricity and other marketing programs should lead to updated recommendations on specific resources during the year.

Some of the options available should current initiatives appear to be delivering below expectations and/or demands exceed projections are:

1. Preparation of the Keenleyside and Peace Site C projects for in-service as early as

1997. This would require project licensing by 1990. Approval for Keenleyside and Murphy Creek would be applied for together, given their inter-relationship.

2. Early negotiations with Cominco Ltd. to reach agreement on capacity additions at Waneta and Brilliant stations, and continued work on other Resource Smart projects for possible in-service by the late 1990's.

3. Continuation of studies and discussions with the Bonneville Power Administration to seek an expanded coordination agreement that could contribute some additional firm energy to the B. C. Hydro system.

4. Renewed attempts to obtain some energy supplies from independent power producers, through negotiations.

5. Advance engineering work on Lower Columbia projects such as Murphy Creek and possibly Border for availability of a block of 3000 GWh by the early 2000's.

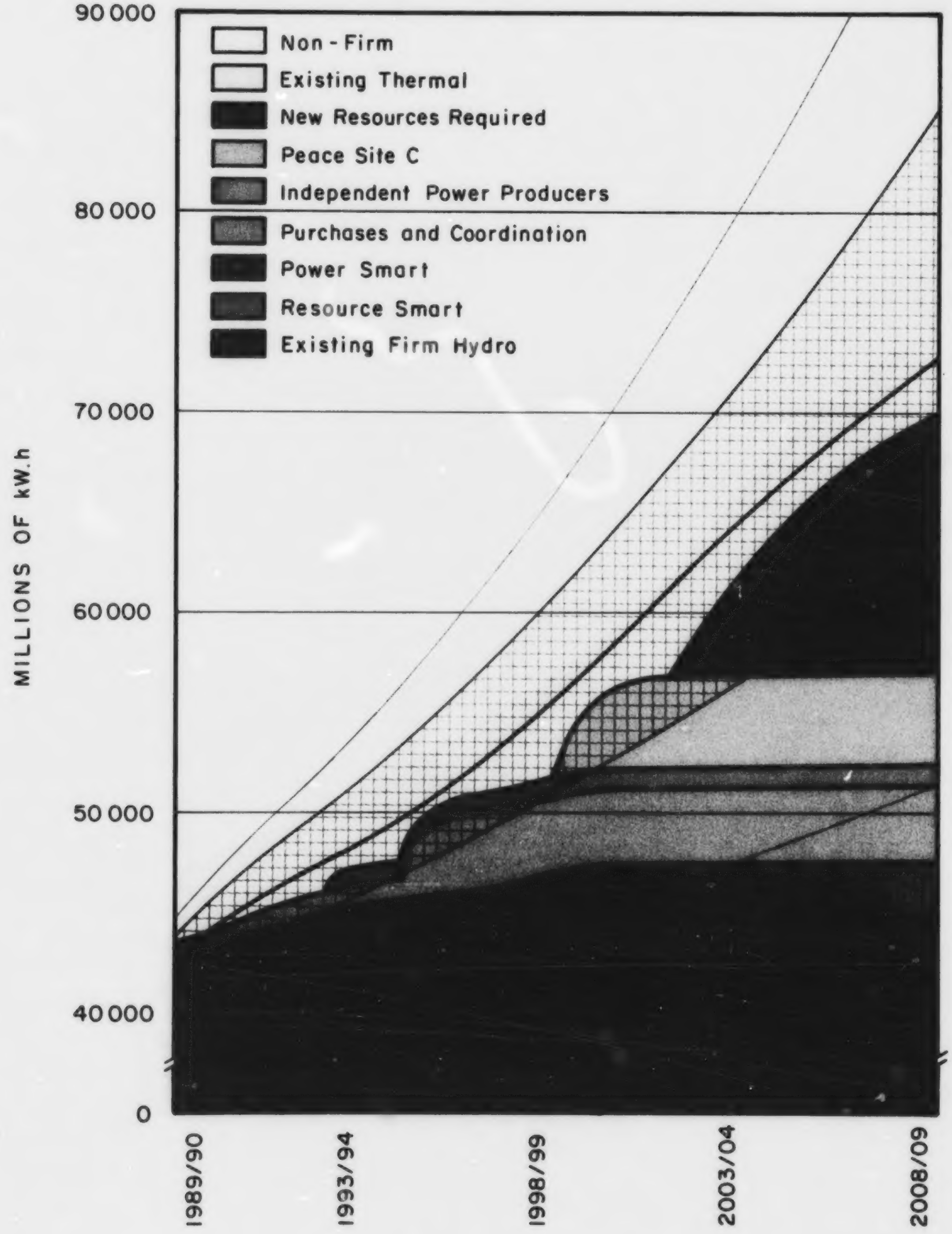
6. Continuing encouragement of projects to utilize wood waste and municipal solid waste, and other cogeneration and load displacement initiatives by municipal and industrial establishments.

7. A review of rate structures that would focus on both efficiency and economic development objectives.

The program of engineering surveys and investigations currently underway should ensure that sufficient options remain available to B. C. Hydro. In addition, monitoring and evaluation systems are being designed and will be put in place gradually during 1989 to assess progress by Power Smart programs. These systems should provide an indication of whether programs are achieving their targets both in terms of load reductions and budgeted costs. Monitoring and evaluation of Power Smart programs will constitute an ongoing process that should not only facilitate management of the programs but also help planning of other resources to meet future demands.

EXHIBIT 5-1

# RECOMMENDED RESOURCE PLAN TO MEET RANGE OF FORECAST DEMANDS



MARCH 1989

EXHIBIT 5-2

# B.C. HYDRO INTEGRATED SYSTEM TRANSMISSION ADDITIONS TO YEAR 2000

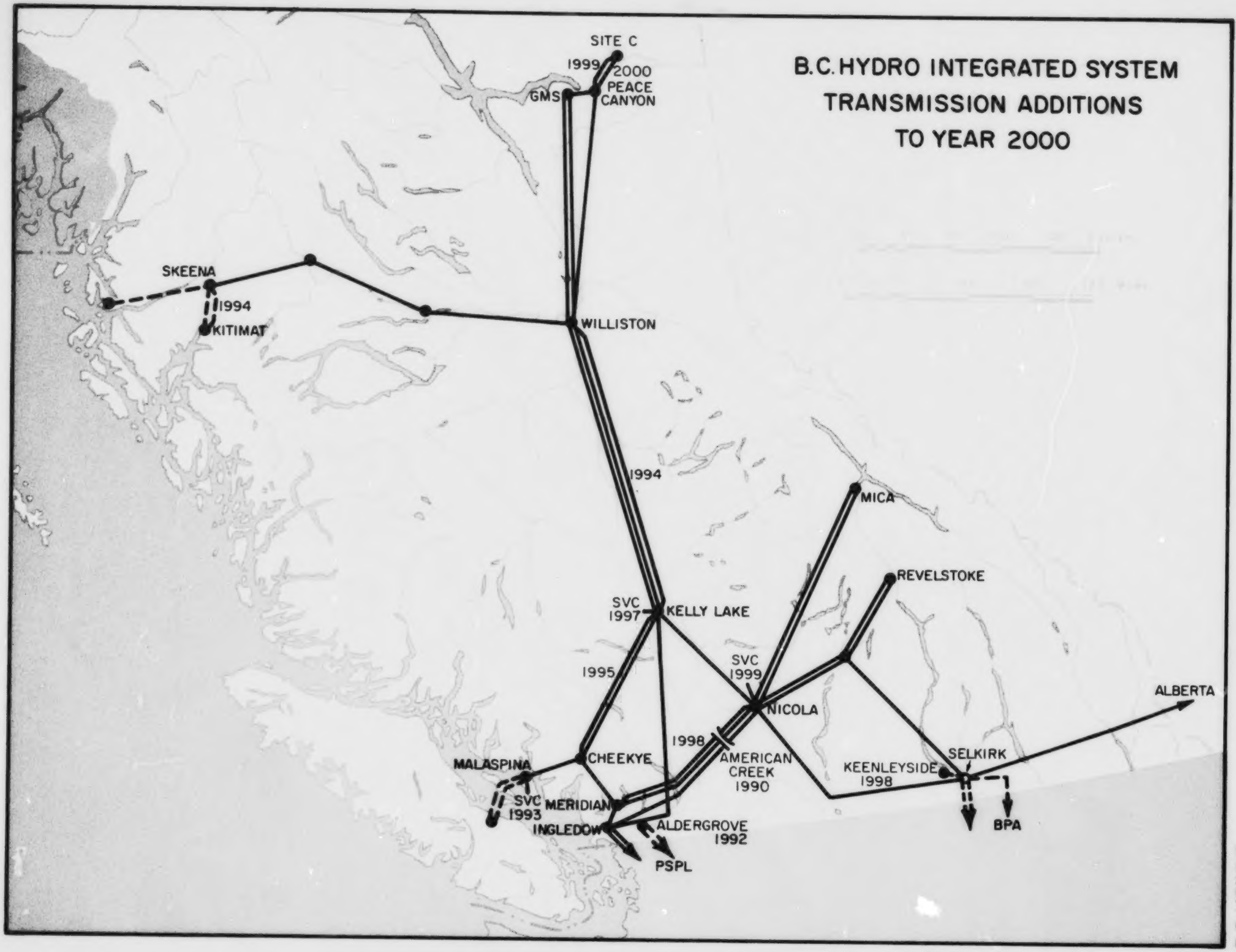
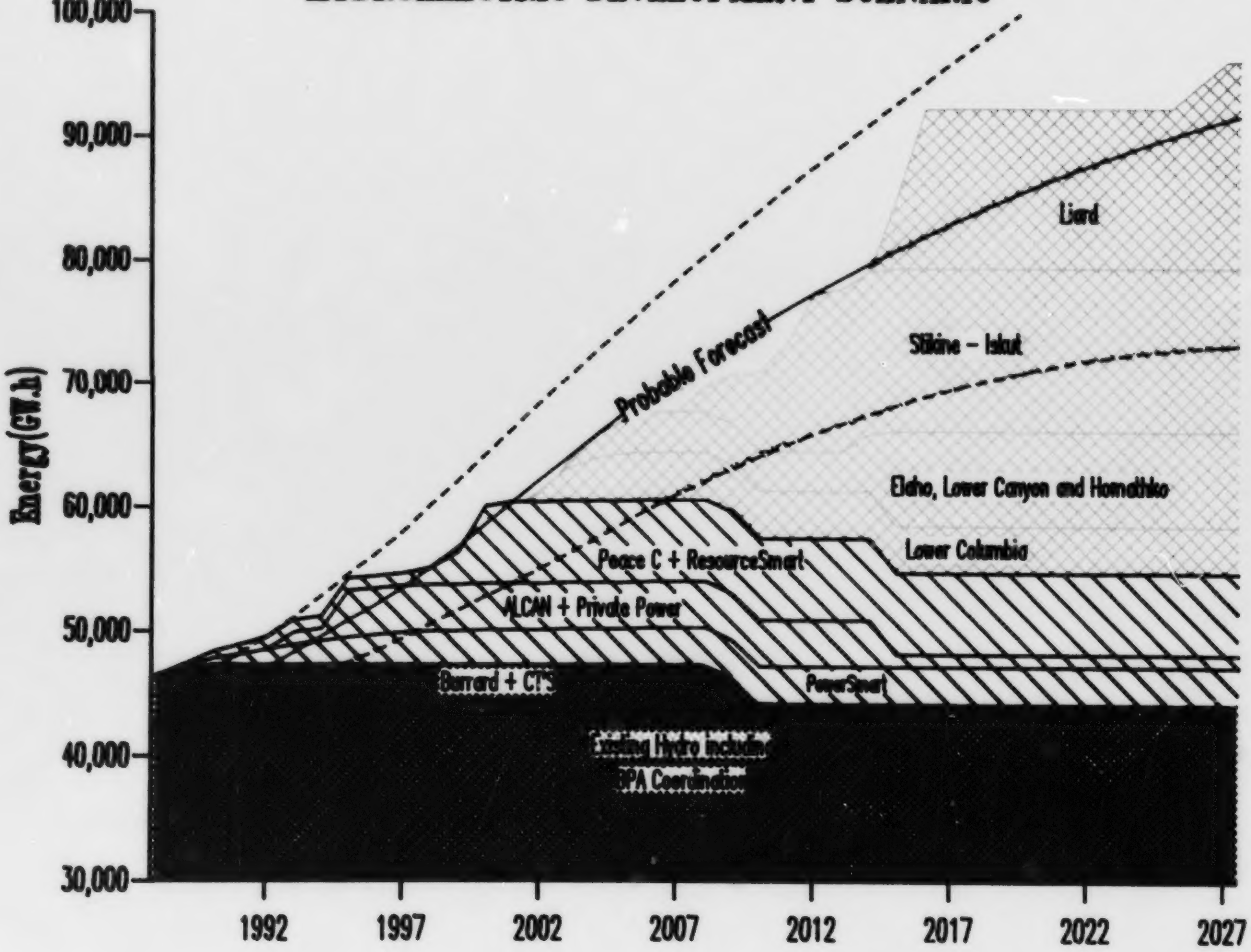

SITE C
1999
2000
GMS
PEACE CANYON
SKEENA
1994
KITIMAT
WILLISTON
1994
MICA
REVELSTOKE
SVC 1997
KELLY LAKE
1995
SVC 1999
NICOLA
ALBERTA
1998
AMERICAN CREEK 1990
KEENLEYSIDE 1998
SELKIRK
MALASPINA
CHEEKYE
SVC 1993
MERIDIAN
INGLEDOW
ALDERGROVE 1992
PSPL
BPA

EXHIBIT 5-3

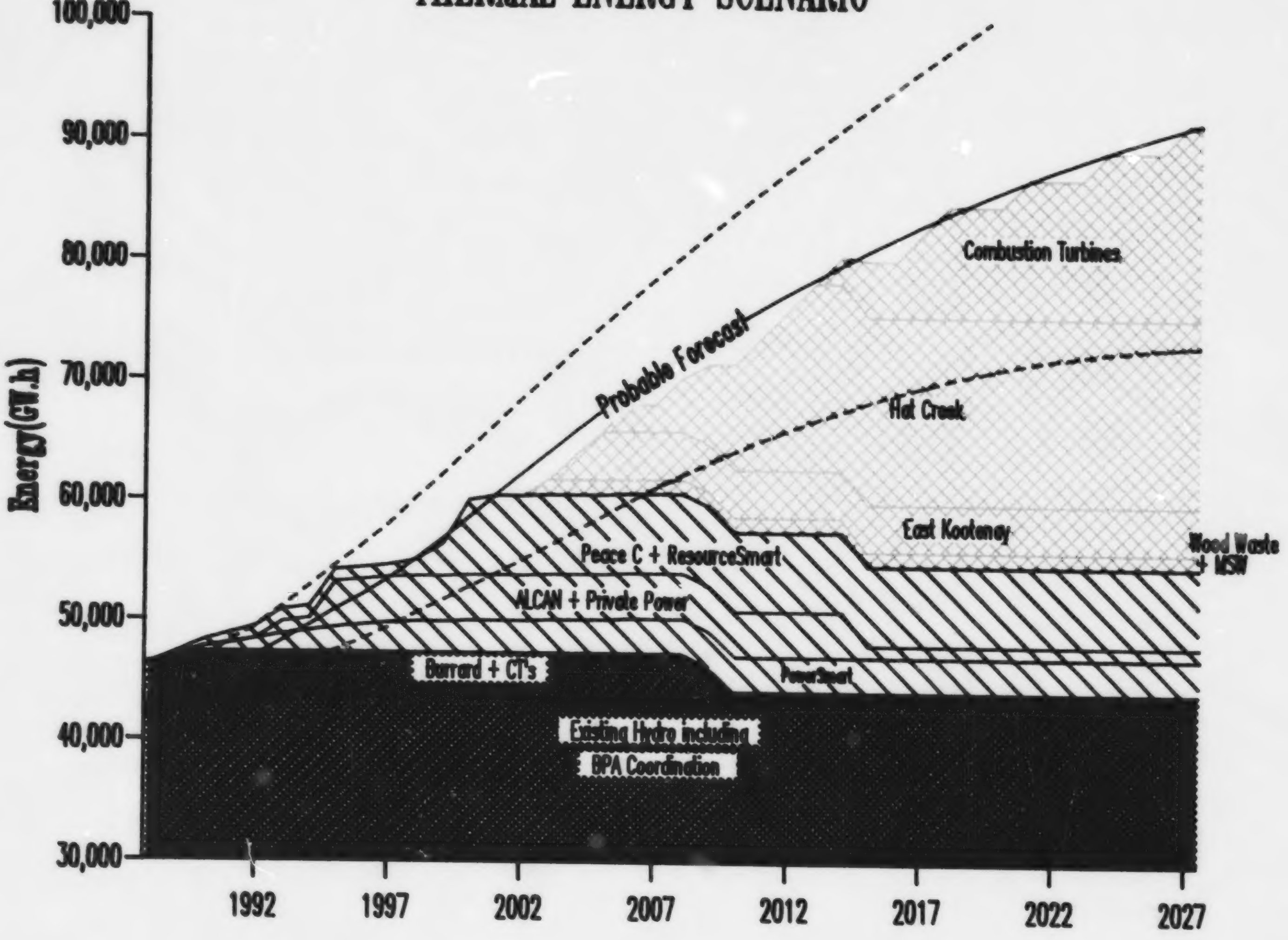
# HYDROELECTRIC DEVELOPMENT SCENARIO



APR 1989

EXHIBIT 5-4

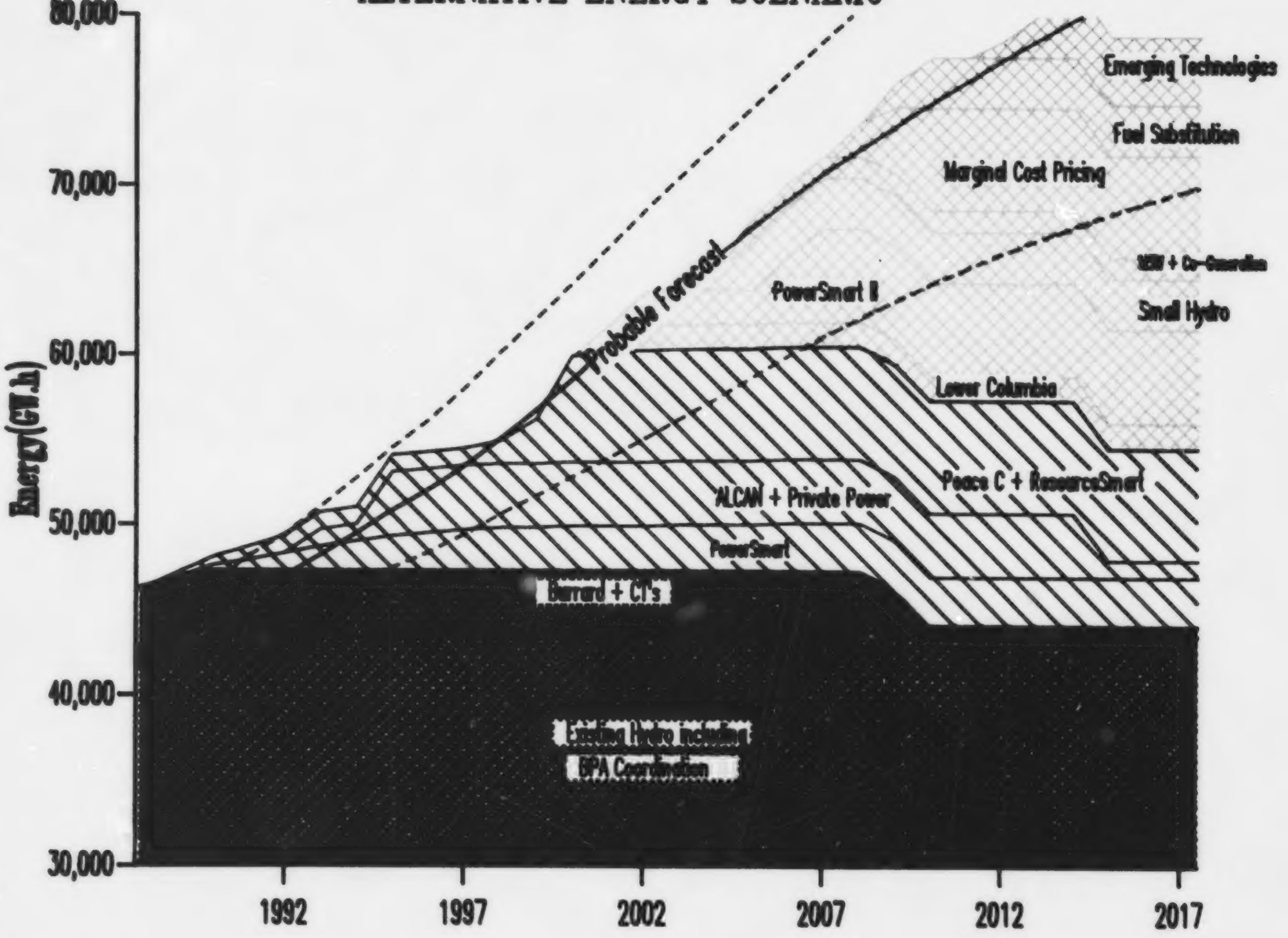
# THERMAL ENERGY SCENARIO



APR 1989

EXHIBIT 5-5

# ALTERNATIVE ENERGY SCENARIO



APR 1989

# ACTION PLAN

The following actions will be undertaken during fiscal year 1989/90 to advance implementation of the recommended plan.

## POWER SMART PROGRAMS

B. C. Hydro will promote Power Smart actively in 1989/90 and will build upon initiatives started in 1988 such as the High Efficiency Motor program. Power Smart will be promoted across the province through the media, and a complete review of marketing publications is also underway.

Key new programs will be introduced. The residential sector will be addressed through the release of the Quality Plus program for new homes, offered in conjunction with other organizations. Existing homes fall under the Home Checkup program, which will include promotion of energy efficient appliances and gas water heating. A comprehensive lighting package will become available for the commercial sector, while an adjustable speed drive program will be released to industrial customers. B. C. Hydro will offer municipal building audits to communities across the province. Schools will also participate, to increase student's awareness of energy efficiency.

Testing and development for new initiatives will also continue, including retrofit programs, more efficient building designs and controls, and high efficiency lighting systems. Programs will be launched in future years as opportunities arise.

## PURCHASES AND COORDINATION

A final agreement is expected to be signed with Alcan for the purchase of the output of the Kemano Completion Project for a twenty-year period beginning in 1995. The agreement will also include coordinated operation of Alcan and B. C. Hydro's systems.

It is expected a formal agreement will be signed with the Bonneville Power Administration for coordinated operation of the Columbia River System. An agreement could lead to studies of further coordinated operation between B. C. Hydro and Bonneville Power Administration.

Studies of coordinated operation with the Alberta Integrated System will continue with the intent of establishing principles for an agreement by the fall of 1989. This year's studies will attempt to identify practical coordination and operational scenarios, taking into consideration transmission limitations.

## INDEPENDENT POWER PRODUCERS

Requests for proposals for up to 150 MW of independent power from projects greater than 5 MW will be evaluated after the closing date of 30 April 1989. A second RFP is expected to be issued in the fall of 1989 with the amount yet to be decided. Proposals under 5 MW based on a fixed price will be issued in April and evaluated during 1989 and contracts awarded later in the year.

## MAJOR PROJECTS

Preparatory engineering activities will continue on the Keenleyside and Peace Site C projects. This activity represents a significant element in B. C. Hydro's contingency planning to meet uncertain future load growth. The projects are currently scheduled for 1998 and 1999 respectively, but may be needed as early as 1997, depending on demand growth and the success of other programs. Work by Klohn-Crippen Consultants is scheduled for possible license applications for Keenleyside and Site C in 1990.

Work on Murphy Creek is to progress so that the project can be available for licensing within the Lower Columbia development strategy. In view of its close interrelationship with the Keenleyside project, it will be necessary to incorporate both projects in an extended application.

Resource scenarios beyond the year 2000 will be evaluated, including Resource Smart projects currently not in the Plan. Studies will continue to assess their viability, leading to Resource Smart program definition in 1989.

## REHABILITATION PROGRAMS

Dam safety rehabilitation/remedial work will continue at the John Hart Generating Station to extend the plant life for the next twenty years, Jordan River Diversion Dam and Downie Slide Adit, and will be initiated at the Alouette, Bear Creek, Comox, Coursier, Wilsey and Strathcona dams.

## TRANSMISSION

Work will be initiated on a third Williston to Kelly Lake 500 kV transmission line and a second Skeena to Kitimat 287 kV transmission line to provide firm transmission capability for the purchase of power from the Kemano Completion Project. Work will also be initiated on a second Kelly Lake to Cheekye 500 kV transmission line to serve load growth in the Lower Mainland and Vancouver Island, and on an upgrade of the 500 kV Peace transmission lines to increase their thermal capacity and ensure safe conductor ground clearances.

## EXPORT MARKET

Depending on the success of marketing efforts in the U.S. and the expressions of interest received until March 1989, POWEREX will issue in the Fall of 1989 an RFP for generation projects intended for export.

B. C. Hydro will continue to study transmission interties with Puget Sound Power and Light and Washington Water Power. Construction of either of these interties in B. C. is subject to POWEREX establishing sales agreements.

# APPENDICES

# APPENDIX I

# CORPORATE POLICIES AND ASSUMPTIONS

## ENVIRONMENTAL POLICY STATEMENT

In the process of generating and supplying electricity B. C. Hydro inevitably affects the natural resources and social structures of the Province. B. C. Hydro has therefore developed an Environmental Policy that formalizes the Corporation's environmental values and its approach to assessing the environmental implications of its actions with the aim of minimizing adverse changes. This Policy covers all aspects of B. C. Hydro's business encompassing existing facilities and operations, new construction, and extends as an essential component into all phases of planning.

The principal elements of this Policy are summarized below and a brief description of how environmental considerations are included in the development of the Resource Plan is provided in the following section.

### Environmental Policy

The primary effort in making B. C. Hydro's actions more compatible with existing natural and social resources focuses on reducing or "mitigating" adverse effects at the point at which they occur. Examples include the use of advanced technology to reduce emissions and discharges and making adjustments to the location of project facilities to avoid sensitive areas. In situations where this is not possible B. C. Hydro will evaluate the resource losses and initiate programs to compensate for such losses. This has been a long standing principle and has been successfully applied at many locations. For example, Hill Creek Hatchery on the Arrow Lakes was funded by B. C. Hydro to compensate for fisheries losses associated with the Arrow Projects. In addition to compensation in its traditional form, B. C. Hydro will also evaluate and implement enhancement programs which go beyond strict compensation guidelines, where such opportunities exist. B. C. Hydro's facilities, particularly dams and transmission lines, use large areas of our province. Opportunities exist for other uses of these lands and lakes, for example recreation and Christmas tree farms, and B. C. Hydro is committed to the multiple use of these resources wherever practical. Inevitably all of B. C. Hydro's actions affect the people of the province and the need to include the views, desires and concerns of the citizens of B. C. in the development and management of our activities is both required and desired. Accordingly, B. C. Hydro is committed to a consultative process with all levels of government and the public in pursuing these programs.

### Resource Plan

In keeping with the above Environmental Policy all projects considered for future development by B. C. Hydro are subjected to environmental assessments. Generally these assessments proceed through several stages from a broad overview to detailed evaluation. The results of these examinations, integrated with engineering, economic, regulatory and energy requirement factors, are incorporated in the Resource Plan.

This overall process includes two major aspects which affect projects' configuration and timing:

1. Several potential sources of electrical generation are available to B. C. Hydro for consideration, such as river systems, coal, gas, and wind. Each potential source of electrical energy

is examined to determine the most suitable method of realizing this potential. Environmental factors play a major role in determining which "scheme" should be developed.

2. Once the development's conceptual design has been established more detailed evaluations are completed. Intraproject studies permit impacts to be minimized via innovative design and provide information for mitigation and compensation programs.

Public involvement is sought in this process. Input obtained will have a major effect on the type of project proposed and the sequence in which projects are presented for development.

## THE DISCOUNT RATE

While the discount rate is an important parameter in analyzing alternatives, many factors influence investment and project selection decisions (i.e. economic, financial, social and environmental issues), and the weight given to individual factors can vary over time and from project to project. For example, concern for the environment and such factors as the greenhouse effect has increased dramatically in the past few years and may override economic and financial factors in decisions regarding thermal options. It is important that decision makers see the full array of factors and their impacts.

The discount rate is used to convert revenues and expenditures occurring in different periods to a common present value basis. It is critical in comparing projects and in determining power costs, investment returns and the value of foregone alternatives. It therefore influences decisions regarding:

- Independent power producer purchases, Power Smart program incentives and prices for cogeneration.
- Capital versus operating costs, hydro versus thermal, project timing and project sizing.
- Transmission and wheeling costs, connections policy and least cost alternatives for servicing remote communities.
- Resource losses and environmental impacts and the value of foregone opportunities to future generations of British Columbians.

The appropriate discount rate can vary depending on the analysis; there is not a single, correct rate to use in all circumstances:

- A 4% rate net of inflation can be argued for assessing resource losses and environmental impacts and the value of foregone opportunities to future generations. However, a 4% real rate is not appropriate for costing, or discounting, financial assets such as capital invested in plant and equipment as long as the risk-adjusted cost of capital exceeds 4% real.
- A 6% real rate represents the current cost of long-term provincial borrowing, and should be the minimum rate achieved on new investment by B. C. Hydro if it is to avoid financial losses. This rate does not take account of project-specific risk.
- A 7-8% real rate reflects the average pre-tax return to public and private investment in Canada and trade-offs between savings and consumption, and should be used to measure benefits and costs to the economy as a whole, the value of broad programs such as Power Smart and the risk-adjusted cost of capital for new investment.

- A 10% real rate represents the average pre-tax return on investment in the private sector and is important in evaluating incentives for private power development, such as independent power producers and cogeneration.

In conclusion it is important to know when the use of a different discount rate will alter a policy recommendation, as this allows decision makers to focus on the trade-offs involved (e.g. when the least-cost financial option differs from the option that maximizes the social return, or when the discount rate affects decisions regarding the system plan, such as the sizing of penstocks and ultimate plant capacity). Accordingly, it is recommended that major decisions be assessed over the following range of discount rates: 4%, 6%, 7%, 8% and 10%.

The economic evaluation component of final recommendations on a specific decision should be based on the discount rate appropriate to that decision (as above) and justified in the analysis.

## FINANCIAL IMPACTS

Assessment of financial impacts involves examination of the effect that a particular project will have on operating expenses, and thereby its impact on rates. The major expenditure components driving the setting of rates are depreciation, finance charges, taxes, operating and maintenance costs.

When an asset is brought into service, the depreciation on the new asset plus the financing charges related to the debt incurred to finance its construction become costs to be recovered from B. C. Hydro ratepayers. These costs are front-loaded since depreciation is calculated on a straight line basis while the finance charges decrease as the debt is being retired.

Alternatively, rather than building and owning an asset, it may be possible to buy the energy output of the facility. Depending on how the price is established, the annual purchase costs may be less than the annual costs of ownership and thereforehave less of an impact on B. C. Hydro ratepayers. However, unless the purchase contract is for the economic life of the asset, the present value costs of the purchase alternative may be higher than that of ownership.

In the past, the assessment of financial impacts has not been a major factor in resource planning, since the emphasis was on selecting among various (primarily hydro) projects and these would all have similar impacts on rates. With the new policies being adopted by B. C. Hydro for Resource Planning, consideration of financial impacts is becoming increasingly important. During 1989 specific methods for incorporating financial impacts into the Resource Planning framework will be developed.

## TAXES

B. C. Hydro pays water rental fees, grants and school taxes to provincial and municipal governments. The table below summarizes the total taxes paid over the last five years, by comparison with revenues and identifiable assets (for the electric service only). Total taxes have ranged from 17% to over 20% of electric service revenues during that period. Water rentals are currently calculated at the rate of 0.4¢/kWh (energy) plus and $2.85/kW (capacity). Hydroelectric project operating costs assume that water rentals will increase tied to B. C. Hydro rates after 1989.

| Fiscal Years (Apr to May) | Electric Service Revenues ($ million) | Identifiable Assets ($ billion) | Taxes ($000) |
|---|---|---|---|
| 1987/88 | 1.72 | 8.45 | 296 |
| 1986/87 | 1.58 | 8.61 | 319 |
| 1985/86 | 1.65 | 8.69 | 309 |
| 1984/85 | 1.51 | 8.79 | 288 |
| 1983/84 | 1.23 | 8.62 | 251 |

## CORPORATE OVERHEAD

Overhead costs are allocated to B. C. Hydro projects as a function of their size, which in turn is characterized by the expenditures involved. The table below provides an approximation.

| Project Total Cost* | Overhead Rate |
|---|---|
| (millions of dollars) | % |
| to 0.27 | 16 - 20 |
| 0.27 - 0.60 | 14 - 15 |
| 0.60 - 1.2 | 12 - 13 |
| 1.2 - 2.4 | 10 - 11 |
| 2.4 - 6.0 | 8 - 9 |
| 6 - 11 | 7 |
| 11 - 26 | 6 |
| 26 - 95 | 5 |
| 95 - 1020 | 4 |
| above | 3 |

**Note:** *Including allowance for inflation.

## OPERATING COSTS

**Fixed operating costs** summarized below are based on B. C. Hydro's past operating experience, although no recent reviews have been conducted. They include:

- Operation and Maintenance
- Administration and General Expense
- Insurance
- Grants, School Taxes
- Interim Replacement

**Variable costs** include primarily fuel costs but also the energy portion of the water rental fees for hydroelectric projects (1988 dollars). Fuel costs shown are current, but are subject to potential significant changes in the future.

| Project Type | Fixed Annual Cost* | Plant Life (years) | Variable Cost (¢/kWh) |
|---|---|---|---|
| Hydroelectric | 1.8 | 70 | .4 |
| Thermal (gas/oil) | 4.0 | 35 | 1.5 (Burrard) |
| Thermal (coal) | 2.2 | 35 | 0.75 (Hat Creek) |
| Combustion Turbine | 3.0 | 30 | 7.0 |
| Transmission (steel) | 1.9 | 45 | - |
| Transmission (wood pole) | 1.9 | 30 | - |
| Substations | 1.2 | 30 | - |

**Note:** *As a percentage of total project construction cost, i.e. excluding corporate overhead and interest during construction.

# APPENDIX II

# TECHNICAL PLANNING CRITERIA AND ASSUMPTIONS

## EXISTING B. C. HYDRO INTEGRATED SYSTEM

The capability of B. C. Hydro's existing integrated system is summarized in Exhibits II-1 and II-2.

The system is predominantly hydroelectric with 29 hydro plants; one conventional thermal plant (Burrard) and two gas turbine plants. The total nameplate capacity is 10 390 MW.

Estimates of the energy capability of the existing system (and other potential projects) are based on reservoir simulation studies using historic streamflow data which extends from October 1940 through September 1985. The 45-year period of record of average monthly stream flows is assumed to be representative of the range of inflows that may occur in the future.

The simulation of the existing system was separated into the following distinct components:

1. The output of small hydroelectric projects such as Aberfeldie, Elko, Falls River, Shuswap, Spillamacheen and Walter Hardman was estimated from historic generation records.
2. Projects such as the Bridge, Campbell and Stave River systems as well as Buntzen, Cheakamus, Wahleach, Whatshan and other small hydroelectric projects were operated to maximize at site and downstream generation. Combined, these systems account for about 17% of the existing firm hydro capability.
3. The Columbia River hydroelectric system was assumed to be operated in accordance with the 1988 Assured Operating Plan (AOP) for Columbia Treaty storage. The operation of the Columbia River system varies somewhat for each load year. The 1988 AOP was chosen as being most representative of expected future operation amongst the available plans.

The impact of operations permitted under an agreement with BPA relating to the use of Columbia River Non-Treaty storage was also included. About 1 MAF of non-treaty storage was emptied each year during the drawdown period from September to January and was subsequently refilled in the period from June to August. This non-treaty operation was adjusted in response to system needs for various streamflow conditions.

4. The Peace River system generation was adjusted to meet system requirements after the generation at other projects has been determined.
5. Generation at the Burrard Thermal Plant, gas turbine plants and amount of energy purchased was adjusted to maintain Williston Lake elevations at or above desired levels.

### FIRM ENERGY CAPABILITY

The critical period was determined by simulating the existing system for the entire period of record and iteratively increasing the monthly loads proportionately. The largest annual load that can be served without deficits defines the firm energy load carrying capability (FELCC) of the system. The critical period is defined as the consecutive period of time during which the major system reservoirs are drawn down from full to empty while the system is serving its FELCC. For B. C. Hydro's existing system, the critical period normally extends from September 1942 through April 1946.

The duration of the critical period depends upon the amount of reservoir storage in the hydroelectric system, the amount of firm energy support available from Burrard Thermal, gas turbine plants and a number of other resources that may be available to the B. C. Hydro system and how these resources are committed to support the hydroelectric system.

These other resources include possible energy purchases from Alcan, Alberta and U.S utilities, use of firm gas at Burrard and various other sources. Reliance on these other resources allows the system to serve a load greater than its FELCC.

For the B. C. Hydro system, this operation also impacts the length of the critical period. Serving its normal FELCC, the reservoir system filled in August 1942 and then gradually drew down to empty in April 1946. However, due to reliance on other resources, the system will generally be required to serve a load greater than its FELCC. In the simulation studies, it was assumed that this higher load would be served by B. C. Hydro resources (no purchases) in the first few years of a critical period. This reduced the probability of requiring support from other resources. However, as a consequence, Williston reservoir experiences greater drawdown and, in the studies, did not fill in the freshet of 1942. As the critical period continued the reservoirs continue to draw down, but at a slower rate as the output of the hydroelectric system was reduced and reliance on other resources increased. Since the reservoir did not refill in 1942 the critical period was extended to cover the 5 1/2-year period from November 1940 through April 1946.

The capability of the existing system for the historic period of record is illustrated in Exhibit II-2. It includes the countribution of thermal units as well, as defined below.

The 912 MW Burrard Thermal plant near Vancouver has a capability of about 3430 GWh/year when running on "valley" gas. "Valley" gas is surplus natural gas, seasonally available between March and October, when the daily requirements of B. C. Gas are less than their firm supply. Burrard's firm energy capability on valley gas is 3170 GWh/year. The firm energy capability could be increased by 2000 GWh/year if a firm gas contract were arranged to provide fuel during those months when insufficient valley gas is available to run the plant at its maximum capability. The cost of operating the plant with this type of contract would be about one and a half times the cost of operating the plant on valley gas and the flexibility to reduce its output may be limited.

B. C. Hydro's two gas turbine plants are located at Prince Rupert and near Port Hardy on northern Vancouver Island. They are primarily intended to provide short-term energy during transmission interruptions in these areas. It would be possible to produce as much as 550 GWh/year from these plants to supplement the hydroelectric system under critical water conditions.

## AVERAGE ENERGY CAPABILITY

The average energy capability of the system is the average output of the generating stations over the 45-year period of record.

## RESOURCE PLANNING CRITERIA

### RESOURCE SCHEDULING METHODOLOGY

Plant additions and energy purchases are scheduled so that the expected cost of meeting domestic energy demands over the long-term is minimized.

A mathematical procedure is used which considers all possible combinations of energy forecasts, hydroelectric system streamflow conditions and resource availabilities. The procedure calculates the "expected" usage of each resource. The schedule of new resource additions is adjusted to balance the long-term cost of generation additions against the cost of using existing resources over the short-term, on a probabilistic basis.

Using this procedure, a Resource Plan is selected to serve the range of possible load forecasts most economically. The plan provides sufficient flexibility that higher load outcomes can usually be served by resorting to higher-cost resources.

In some adverse combinations of load, streamflow and resource availabilities, not all load can be served. The probability and extent of such deficits is calculated and serves as a measure of the risk inherent in each alternative plan considered. If major increases in load growth should occur in future, it is assumed that subsequent Resource Plans would incorporate project advancements as necessary to reduce risks to acceptable levels.

### ENERGY RESOURCES

The following generation resources are considered to meet the range of forecast loads:

1. **Hydroelectric resources.** Their firm energy capability is estimated assuming a repetition of historic critical water conditions. Critical water conditions are defined as the lowest streamflow sequence for the hydro system as a whole during the 45-year period from 1940/41 to 1984/85. Natural inflows to major reservoirs averaged approximately 15% below average during the 1940-1946 critical period.

   The capability of all existing and proposed new hydroelectric plant is simulated over these 45 water years to provide an estimate of the probability distribution of hydroelectric energy. In many of the better streamflow periods (i.e. about 80% of the time) additional secondary hydroelectric energy will be available. When available, this secondary energy would be used to serve remaining domestic load and then to reduce any higher cost energy purchases, and thermal generation. Remaining secondary energy that might otherwise be spilled would be offered for sale in interruptible markets in British Columbia, Alberta and the United States.

2. **Burrard Thermal.** It is assumed that Burrard would be operated on "valley" gas which is seasonally available between March and October, when daily natural gas requirements are less than B. C. Gas's firm supply. Current estimates of "valley" gas availability would permit a maximum annual Burrard output of about 3400 GWh. During a recurrence of the critical period, Burrard could contribute an average of 3170 GWh annually, corresponding to a 40% annual capacity factor for the 900 MW plant.

3. **Existing and future thermal generation** plant whose maximum annual capacity factors

could range from 60% to 80%, depending on the type, size and age of individual units.

Higher cost thermal plants such as gas turbines would be expected to operate only during very low streamflow periods or to meet very high loads.

4. **Firm Purchase Contracts.** This would include energy from Alcan under the long term purchase agreement currently being finalized.

5. **Private Power Producers.** An allowance for up to 150 MW and 1000 GWh/ year energy beginning in 1994, was made for this year's Plan, pending a response to the Request for Proposals issued in December 1988. See RFP: "Purchase of Electricity Supply and Load Displacement (project greater than 5 MW) for B. C. Hydro's Integrated System.

6. **Downstream Benefits Arising from the Columbia River Treaty.** The Canadian entitlement to downstream power and energy benefits resulting from the operation of storage at the Duncan, Arrow and Mica projects was sold to the United States for a period of 30 years from the commencement of operation of each project. These 30-year periods begin to expire in 1998/99, at which time the benefits will revert to British Columbia.

   Downstream benefits are assumed to vary uniformly between values estimated for Low and High growth rates in the Pacific Northwest. No correlation between Pacific Northwest and B. C. Hydro load growth is assumed.

   Exhibit II-3 presents a projection of the Canadian entitlement to downstream benefits.

7. **Other energy resources.** These may include additional energy from Burrard Thermal with a firm gas contract; spot energy purchases from Alcan, TransAlta or U.S. Utilities; and purchase of co-generated energy from industrial customers. Energy from these sources is assumed to vary uniformly between their estimated minimum and maximum values.

   It is assumed that sufficient transmission capacity exists to deliver the energy from these resources.

## POWER SMART PROGRAMS

The 1988 load forecast already includes energy savings which are expected to arise from conservation measures voluntarily adopted by Hydro's customers in future. Additional energy savings possible through adoption of the Power Smart programs outlined in Section 4.1 would lower demands further. A single estimate of energy savings was used this year. Transmission and distribution losses were added to the original sales figures projected by marketing staff.

Exhibit II-4 summarizes the projected Power Smart energy savings from the residential, commercial and industrial programs currently included in the Resource Plan.

## RELIABILITY

B.C. Hydro requires both that an adequate capacity margin to meet peak loads be maintained and that the maximum energy shortfall in any future year be less than a certain percentage of the total annual energy demand.

### 1. Peak Capacity

The peak capacity of the electric system is designed to meet or exceed the forecast one-hour peak demand and to provide a peak reserve margin. B. C. Hydro is a member of the Western Systems Coordinating Council (WSCC), a group of electric utilities serving the western United States and Canada. The WSCC criteria allow member utilities to select one of three peak reserve criteria. B. C. Hydro, like most other utilities throughout North America, has chosen to adopt the loss-of-load probability criteria. This method comprises a probabilistic analysis of simultaneous outages of generating equipment. In the application of this methodology B. C. Hydro has adopted a maximum allowable risk of loss-of-load of one day in 10 years. That is, the probability that there would be insufficient generating resources available to meet the forecast daily peak load should be one-tenth of a day per year or less.

Allowance is made for the emergency peak reserve that may be available to B. C. Hydro through existing interconnections with neighbouring Canadian utilities. The 500 kV interconnection between B. C. Hydro and TransAlta is assumed to increase B. C. Hydro's firm peak load carrying capability by 400 MW. No allowance is made for possible peak load reduction by curtailment of supply to large industrial customers during winter peak days. No allowance is made for emergency peak support through our interconnection with the U.S. Northwest Power Pool.

Since B. C. Hydro's integrated system is predominantly hydro, peaking capabilities have usually been sufficient to meet the loss-of-load probability criterion of one day in ten years. Thus the largest loads that can be served without incurring excessive deficits have largely been determined by the system's firm energy load carrying capability (FELCC, as explained earlier in this Appendix).

Exhibit II-5 provides a summary the firm capacity reserve for the 1989 Resource Plan.

### 2. Energy

The energy reliability criterion currently in use by B. C. Hydro assumes the full range of probabilistic combinations of load uncertainty and resource availability, and limits the expected amount of unserved energy (or energy shortfall) in any given year to a maximum of 0.8% of the total annual energy demand. In the near term, changes in load growth must be served from the existing and currently planned system. However, since major projects generally have construction lead times of about ten years, increases or decreases in load after this time can be accommodated by advancing or deferring project schedules. For this reason, in the application of the energy reliability criterion it is assumed that the demand forecast range (band width) remains approximately constant after ten years.

Exhibit II-6 illustrates the expected resource use to serve forecast probable loads, according to the 1989 Resource Plan.

## TRANSMISSION REQUIREMENTS

**The bulk transmission system** must be capable of withstanding a single contingency outage during peak load periods or other high-stress conditions and meet certain performance standards relating to maximum circuit loadings (limited by conductor temperatures, ground clearances, voltage drops and stability conditions); and to meet minimum security specifications (whereby no single transmission circuit outages should cause loss of load or generation, overloading of transmission circuits or undervoltages). In addition, as a member of the Western Systems Coordinating Council, B. C. Hydro must demonstrate that disturbances on the B. C. Hydro system will not cause cascading disturbances into neighbouring utilities.

**Area transmission** standards vary. In general, all peak forecast loads, including industrials, are to be served, but the security of service over peak varies depending on location, loading and customer requirements.

**Station** arrangements also vary from important 500 kV and bulk supply stations to small distribution substations. A proper balance is sought between the needs for reliability, importance of the station in the network, maintainability and cost. Important stations are arranged to allow any single element to be out of service yet maintain electric supply.

**Control and communications** facilities are also provided to meet security and reliability objectives; to allow operation of the electric system; and for administrative support.

The cost of the major additions to transmission and stations equipment required to transmit energy and capacity to the load centres are included in each alternative plan evaluated.

Further information on additions to the system in the above mentioned areas can be found in the document "Electric System Development Plan", which contains a description of the planned additions to the system over the next ten years, and the underlying planning criteria utilized. This report is issued annually by the System Planning Division.

EXHIBIT II-1

## PROJECT ENERGY AND CAPACITY DATA
## EXISTING PROJECTS

| | Capacity (MW) | | Capability (GWh) | |
|---|---|---|---|---|
| **Project** | **Nameplate** | **Dependable** | **Average** | **Critical** |
| | | | Oct.'40- Sep.'85 | Nov.'40- Apr.'46 |
| Existing System | | | | |
| G. M. Shrum | 2 416 | 2 680 | 13 110 | 12 250 |
| Peace Canyon | 700 | 700 | 3 390 | 3 290 |
| Mica*[1] | 1 736 | 1 600 | 7 380 | 6 770 |
| Revelstoke*[1] | 1 843 | 1 843 | 8 180 | 7 580 |
| Seven Mile*[2] | 607 | 590 | 3 330 | 2 790 |
| Kootenay Canal*[3] | 529 | 529 | 3 240 | 2 470 |
| Other Hydro | 1 501 | 1 535 | 7 820 | 7 410 |
| SUBTOTAL | 9 332 | 9 477 | 46 450 | 42 560 |
| Burrard | 912 | 0 | | 3 170 |
| Gas Turbines and Purchases | 146*[4] | 160*[4] | | 2 270 |
| TOTAL | 10 390 | 9 637 | | 48 000 |

**Notes:**

*[1] The energy capability of Mica and Revelstoke allows for transactions under the Columbia River Non-Treaty Storage Agreement.

*[2] Seven Mile energy is net of compensation for encroachment on the Boundary tailwater upstream.

*[3] Kootenay Canal energy is the sum of generation at Kootenay Canal plus WKPL and Cominco projects minus the Basic Supply.

*[4] No allowance is made for any peaking contribution from purchases. These values reflect the peaking capability of the gas turbines only.

EXHIBIT II-3

## CANADIAN ENTITLEMENT TO COLUMBIA RIVER TREATY DOWNSTREAM BENEFITS ACCRUING TO BRITISH COLUMBIA*

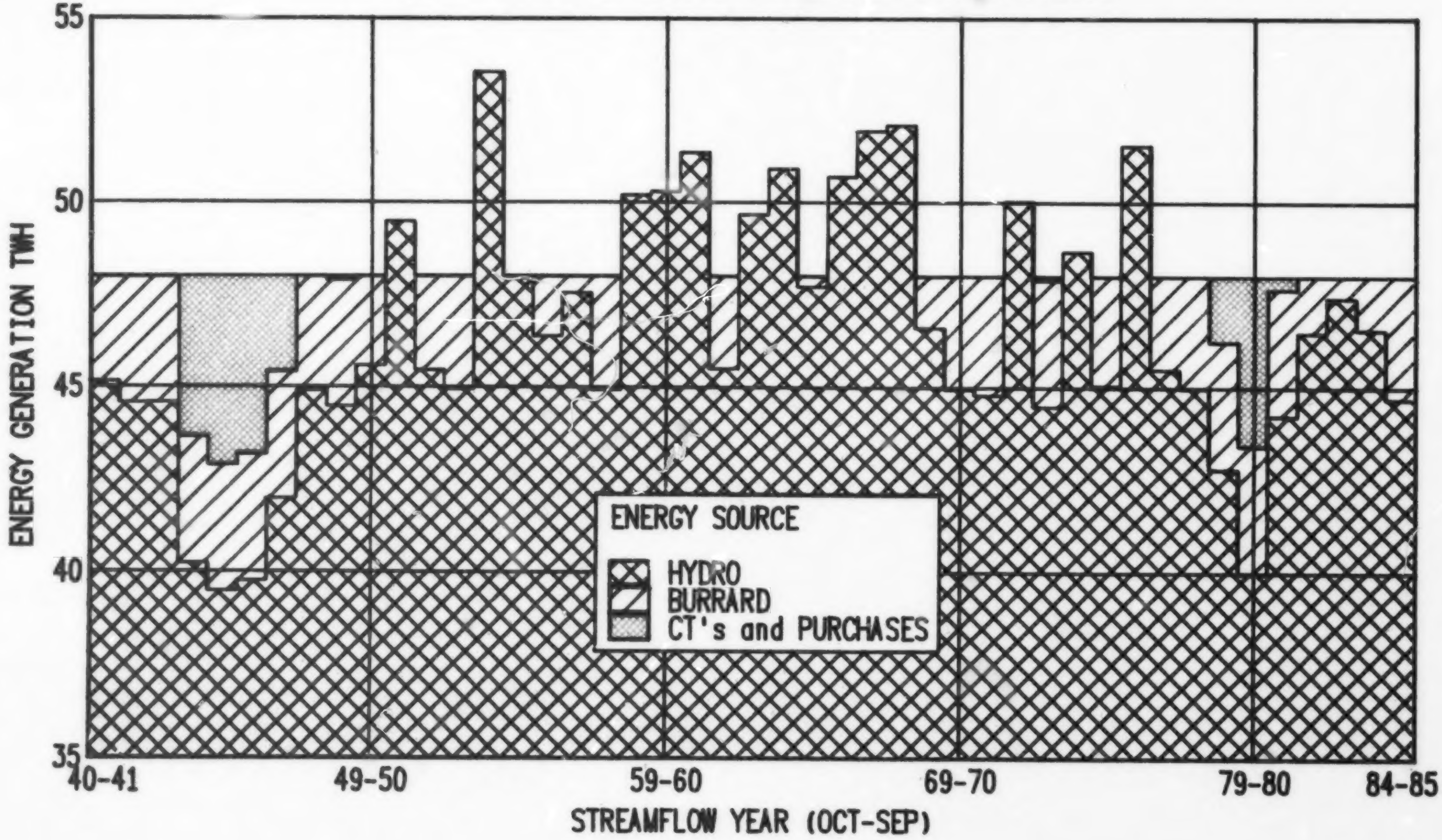
| | | Energy Benefits** (GW.h) | | Capacity Benefits (MW) |
|---|---|---|---|---|
| **Year** | Low PNW Growth | Probable PNW Growth | High PNW Growth | **All forecasts** |
| 1998/89 | 620 | 480 | 360 | 100 |
| 1999/00 | 3670 | 2790 | 2060 | 600 |
| 2000/01 | 3670 | 2760 | 1990 | 600 |
| 2001/02 | 3680 | 2730 | 1920 | 600 |
| 2002/03 | 3690 | 2700 | 1850 | 600 |
| 2003/04 | 6600 | 4810 | 3230 | 1100 |
| 2004/05 | 6620 | 4760 | 3130 | 1100 |
| 2005/06 | 6640 | 4710 | 3030 | 1100 |
| 2006/07 | 6630 | 4660 | 2930 | 1100 |

* According to the Canada - B. C. agreement dated 8 July 1963, these downstream benefits "belong to B. C. absolutely for its own use".

** Estimated Range of Annual Benefits as a function of the growth rate in the Pacific Northwest, based on BPA's 1986 forecast.

EXHIBIT II - 2

# ENERGY CAPABILITY OF THE EXISTING SYSTEM FOR THE HISTORIC STREAMFLOW RECORD



Resource Planning
MAR 1989

EXHIBIT II-4

## ESTIMATED ENERGY SAVINGS BY POWER SMART PROGRAMS

(GW.h)

| Year | Program Energy Savings | Allowance for avoided line losses | Total Estimated Energy Savings* |
|---|---|---|---|
| 1989/90 | 95 | 10 | 105 |
| 1990/91 | 320 | 40 | 360 |
| 1991/92 | 620 | 80 | 700 |
| 1992/93 | 980 | 120 | 1100 |
| 1993/94 | 1340 | 170 | 1510 |
| 1994/95 | 1610 | 200 | 1810 |
| 1995/96 | 1850 | 230 | 2080 |
| 1996/97 | 2030 | 250 | 2280 |
| 1997/98 | 2200 | 270 | 2470 |
| 1998/99 | 2290 | 280 | 2570 |
| 1999/00 | 2350 | 290 | 2640 |
| 2000/01 | 2370 | 290 | 2660 |
| 2001/02 | 2390 | 290 | 2680 |
| 2002/03 | 2420 | 300 | 2720 |
| 2003/04 | 2450 | 300 | 2750 |
| 2004/05 | 2480 | 300 | 2780 |
| 2005/06 | 2520 | 310 | 2830 |
| 2006/07 | 2560 | 310 | 2870 |
| 2007/08 | 2590 | 320 | 2910 |

* Generation required to produce an equivalent amount of energy at the user's premises.

EXHIBIT II - 5

## ESTIMATE OF B.C. HYDRO'S FIRM CAPACITY SURPLUS
## BASED ON THE 1989/90 RESOURCE PLAN

| YEAR | PROBABLE LOAD (MW) | POWER SMART (MW) | NET PEAK LOAD (MW) | GENERATION ADDITIONS | DEPENDABLE CAPACITY Additions | DEPENDABLE CAPACITY Total | REQUIRED RESERVE (MW) | TRANSALTA SUPPORT (MW) | NET REQUIRED RESERVE (MW) | ACTUAL (MW) | RESERVE %LOAD | RESERVE MARGIN (MW) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 89/90 | 7640 | 0 | 7640 | - |  | 9637 | 1125 | 400 | 725 | 1997 | 26.14 | 1272 |
| 90/91 | 7830 | 18 | 7812 | - |  | 9637 | 1125 | 400 | 725 | 1825 | 23.36 | 1100 |
| 91/92 | 8080 | 62 | 8018 | - |  | 9637 | 1125 | 400 | 725 | 1619 | 20.19 | 894 |
| 92/93 | 8230 | 118 | 8112 | - |  | 9637 | 1125 | 400 | 725 | 1525 | 18.80 | 800 |
| 93/94 | 8450 | 187 | 8263 | - |  | 9637 | 1125 | 400 | 725 | 1374 | 16.63 | 649 |
| 94/95 | 8680 | 254 | 8333 | - |  | 9637 | 1125 | 400 | 725 | 1304 | 15.65 | 579 |
| 95/96 | 8910 | 307 | 8603 | ALCAN | 520 | 10157 | 1177 | 400 | 777 | 1554 | 18.06 | 777 |
| 96/97 | 9130 | 352 | 8778 | - |  | 10157 | 1177 | 400 | 777 | 1379 | 15.71 | 602 |
| 97/98 | 9390 | 387 | 9003 | - |  | 10157 | 1177 | 400 | 777 | 1154 | 12.82 | 377 |
| 98/99 | 9670 | 418 | 9252 | KEENLEYSIDE | 124 | 10281 | 1189 | 400 | 789 | 1029 | 11.12 | 240 |
| 99/00 | 9960 | 435 | 9525 | - | 62 | 10343 | 1196 | 400 | 796 | 818 | 8.59 | 22 |
| 00/01 | 10280 | 447 | 9833 | PEACE SITE C | 450 | 10793 | 1241 | 400 | 841 | 960 | 9.76 | 119 |
| 01/02 | 10600 | 450 | 10150 | - | 450 | 11243 | 1286 | 400 | 886 | 1093 | 10.77 | 207 |
| 02/03 | 10910 | 454 | 10456 | - |  | 11243 | 1286 | 400 | 886 | 787 | 7.53 | -99 |

1. The required reserve is computed from loss of load probability studies. It indicates the generation reserve necessary to maintain a 1-day in 10-year risk index.

2. Reserve pooling between the Alberta and B.C. results in a 400 MW reduction in B.C. Hydro's net required reserve.

3. Total resources include 9477 MW of existing hydro resources and 160 MW of gas turbines. The dependable capacity of Burrard is assumed to be zero due to its uncertain fuel supply during winter peak periods.

EXHIBIT II - 6

## B.C. HYDRO ENERGY LOAD AND RESOURCE BALANCE

| FISCAL YEAR | PROBABLE LOAD (GWh) | DOMESTIC INTERRUPTIBLE MARKET (GWh) | MAJOR PROJECT ADDITIONS | | EXPECTED RESOURCE USE | | |
|---|---|---|---|---|---|---|---|
| | | | Generation Additions | Energy (GWh) | Total Hydro (GWh) | POWER SMART (GWh) | Burrard and Purchases (GWh) |
| 89/90 | 43600 | 200 | - | | 43620 | 100 | 80 |
| 90/91 | 44800 | 200 | - | | 44320 | 400 | 280 |
| 91/92 | 46100 | 300 | - | | 45060 | 700 | 640 |
| 92/93 | 47000 | 300 | - | | 45440 | 1100 | 760 |
| 93/94 | 48200 | 300 | - | | 45920 | 1500 | 1080 |
| 94/95 | 49500 | 300 | ALCAN | 2500 | 46360 | 1800 | 1640 |
| 95/96 | 50900 | 300 | - | | 45700 | 2100 | 3400 |
| 96/97 | 52100 | 300 | - | | 46300 | 2300 | 3800 |
| 97/98 | 53500 | 300 | - | | 46780 | 2500 | 4520 |
| 98/99 | 55100 | 290 | KEENLEYSIDE | 1200 | 47560 | 2600 | 5230 |
| 99/00 | 56700 | 280 | PEACE SITE C | 4600 | 49040 | 2600 | 5340 |
| 00/01 | 58500 | 300 | - | | 51980 | 2700 | 4120 |
| 01/02 | 60500 | 290 | - | | 52900 | 2700 | 5190 |

# APPENDIX III

## B. C. HYDRO DEMAND FORECAST

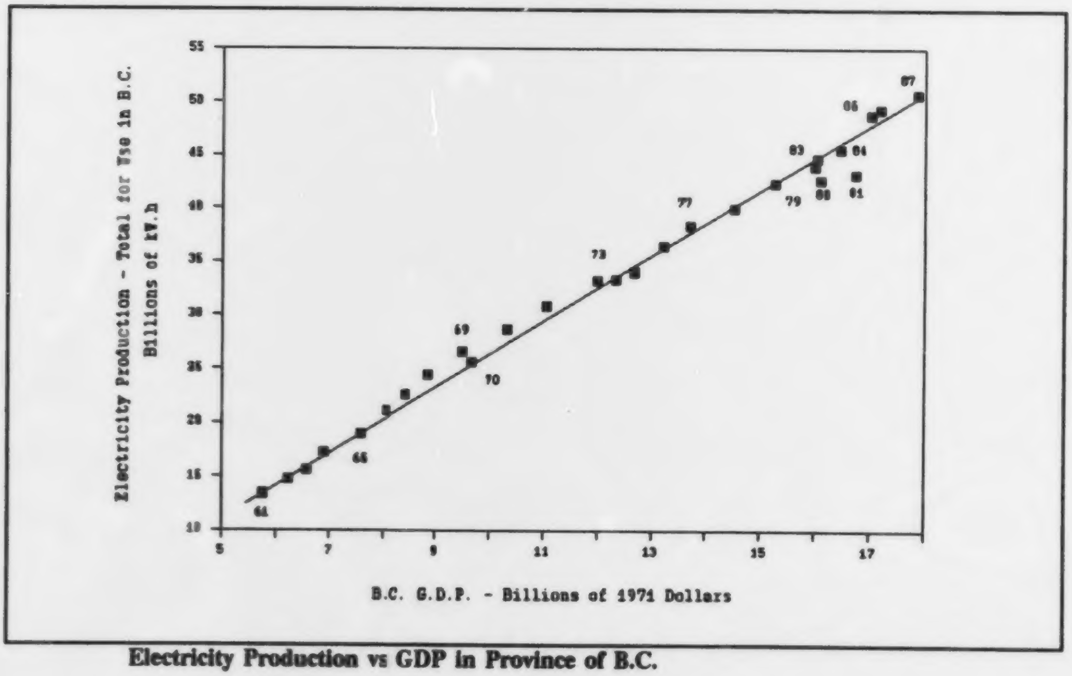
The B. C. Hydro Electric Forecast, as described in this Appendix, includes all domestic demands in B. C.Hydro's integrated areas plus firm export and inter-utility commitments. Firm sales to West Kootenay Power and Light and Seattle City Light (under the Skagit agreement) as well as Point Roberts and Hyder in the U.S. and to Alberta Power in the Peace River are included. Also, energy savings from conservation measures adopted voluntarily by B. C. Hydro's customers are included. The Interruptible Marketing (E+) and Power Smart programs are not included in the forecast because of the interruptible nature of the E+ programs and the use of the Power Smart programs as resource options.

The forecast is prepared on a year-by-year basis for the first 10 years (through 1998/99). The following 10 years (through 2008/09) rely on trend projections tied to the long- term economic outlook.

### ASSUMPTIONS FOR PROBABLE ECONOMIC FORECAST

#### ELECTRICITY USE VS GDP IN BRITISH COLUMBIA

There is a very good historical relationship between growth in electricity use in B. C. and growth in Gross Provincial Domestic Product (GDP) as shown below. On average, from 1961 through 1987, a 1% growth in real GDP has equated to a 1.2% growth in B. C. electricity use.



Electricity Production vs GDP in Province of B.C.

This relationship has held in spite of many factors that could have caused it to deviate, such as promotions to sell more electricity in the 1960's, the turn to serious energy conservation in the 1970's, a trend to electric heating as oil prices increased, the promotion of more efficient electric appliances, and a recent trend to more electrical intensive processes in industry.

While there is no reason to believe that this historical relationship will hold indefinitely, a marked deviation is not expected. This forecast assumes a declining ratio of electricity growth to GDP to slightly under 1.0 over the 20- year period. This reflects a continuing emphasis on efficient energy use, a continuing move towards a service oriented economy and approaching limitations in further development of certain sectors of the electric intensive forest and mining industries.

## ECONOMIC GROWTH

The probable economic forecast is based on the assumption of continuing stable economic conditions; moderate inflation; slowly declining interest rates; steady improvement in the rate of unemployment; and a return to the higher productivity growth rates normally found in stable investment climates. Also assumed is expansion of world trade especially among countries in the Pacific Rim and the United States.

Overall, B. C. economic growth through 1998 is forecast to grow at an annual average rate of 3.0%. For the following ten years through 2008, growth is projected to average 2.8%.

## POPULATION

British Columbia's population is forecast to rise from 2.94 million in 1987 to 3.88 million in 2008, at an average annual rate of 1.4%.

## ENERGY PRICES

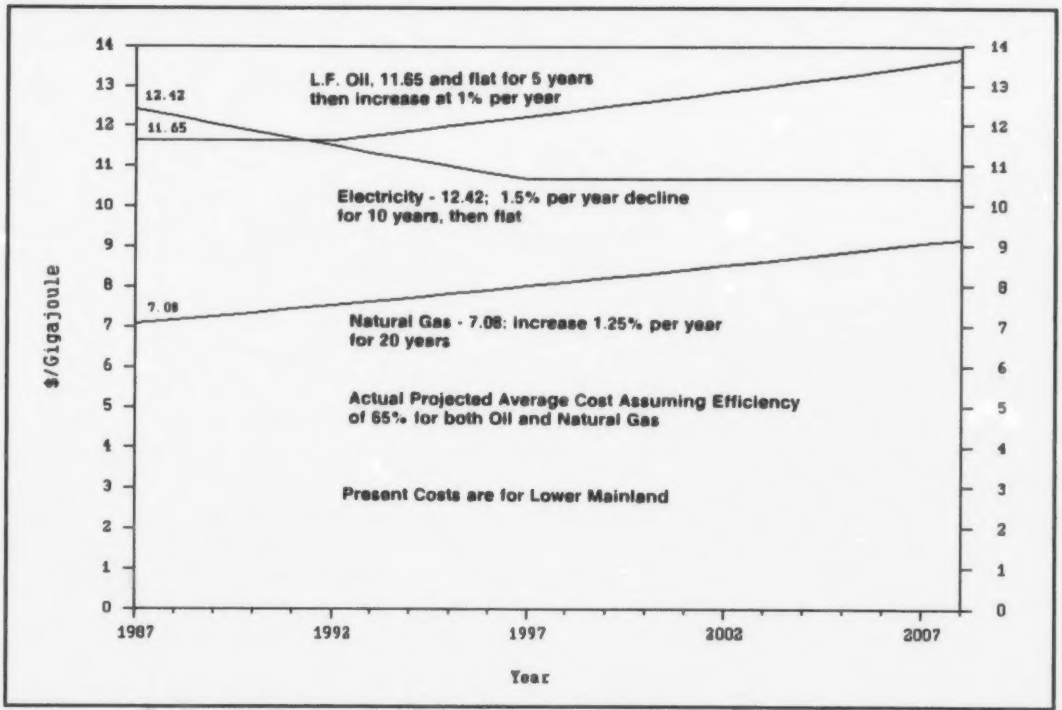
The **electricity price** forecast is based on future revenue requirements which depend on both the cost of existing and additional plant needed to meet load growth as well as other factors such as taxes, export revenues from surplus sales and financial charges. Electricity prices are projected to decline in real terms at 1.5% per year for the first 10 years and remain constant in real terms (i.e. increase at the rate of inflation) thereafter. The result by 1998 is a real price decline of approximately 14%.

The perspective for **crude oil price** to the long term remains uncertain. However, equilibrium levels of long-term crude oil prices are projected to fall between U.S. $15 and $20 per barrel (1988$). Crude oil prices below or above this range will impact supply and demand in a manner which will return prices to the U.S. $15 to $20 per barrel range. This forecast assumed oil prices to remain constant, in real terms, for 5 years and then increase at 1% per year.

**Natural gas prices** will be a function of both market forces and the resolution of industry constraints. In the long term, natural gas prices are expected to increase relative to crude oil prices because North American natural gas markets will tighten before world crude oil markets do, since the world crude oil production surplus is considerably greater than the North American gas deliverability surplus. The wellhead price is thus expected to begin rising significantly in real terms. Distribution costs, however, are expected to remain constant. The result assumed for this forecast is an overall increase of 1.25% per year in real terms.

These natural gas prices translate into fuel prices for the Burrard generating station of 1.3¢/kWh currently, and about 2.1¢/kWh by the late 1990's (in constant 1988 dollars, i.e. before inflation).

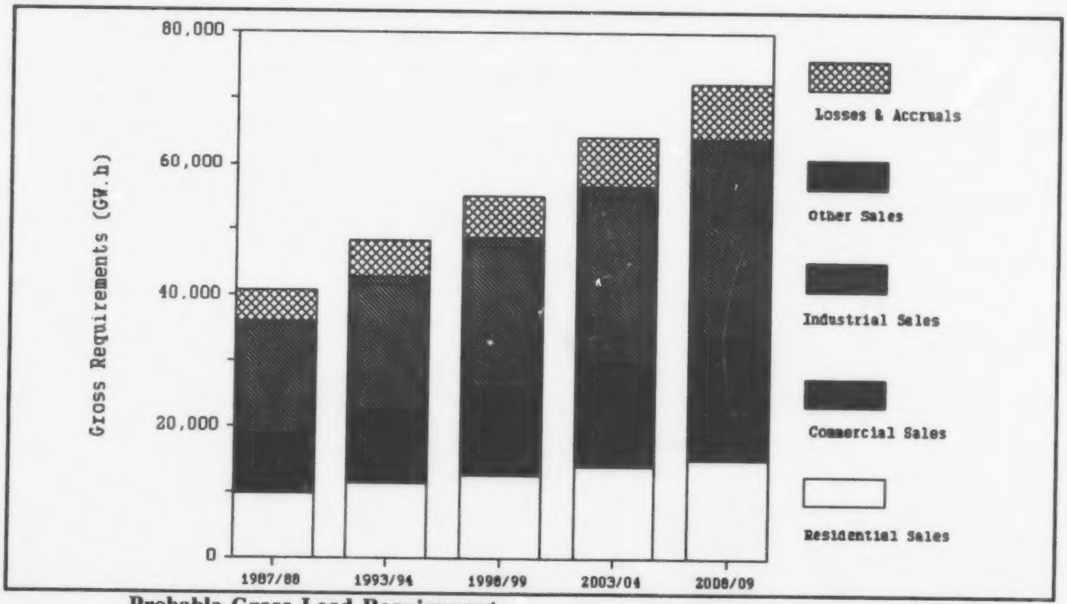
The long-term effect of the outlook for electricity, crude oil and natural gas prices is illustrated for the residential sector in the figure below, which shows efficiency-adjusted costs for residential heating fuels with present Lower Mainland prices. Light fuel oil and natural gas are expected to remain close to the same relative position. Electricity, however, will become relatively cheaper but not to the point of being competitive with natural gas. Thus no significant change in the pattern of fuel use is projected. This same outlook is assumed for the competitive areas within the commercial and industrial sectors.



Residential Heating Real Price Forecast

## 1988 PROBABLE FORECAST

Total gross requirements are projected to increase from 40 793 GWh in 1987/88 to 55 290 GWh in 1998/99 and 72 410 GWh in 2008/09 for an annual average growth rate for the 20-year period of 2.8%. Exhibit III-1 provides details of the projections by sector and the figure below provides a graphical representation for key years.



Probable Gross Load Requirements

Residential sales are projected to be the slowest growth sector. The continuing efficiency improvements in appliances and the high saturation of (and limited introduction of new) electric intensive appliances are the primary reasons for the conservative growth projections.

Commercial sales are projected to grow faster than both residential and industrial. The driving factor is the continuing addition of (relatively) new applications such as office automation, personal computers, etc. The result is a continuing increase in use of electricity by existing customers.

Industrial sales growth is projected to be driven by the pulp and paper sector through the early 2000's when resource availability will limit growth. Mining load is expected to show negative growth with closure of many existing copper mines in the 1990's. New sales are anticipated from the area of smelting, chemicals and new manufacturing. An additional driving factor is the continuing trend to improving productivity via the increased use of electricity.

The growth in peak demand for the integrated system is expected to closely parallel the growth in energy requirements. No discernible change in the annual system load factor is evident from recent history. Influences will come, however, from changing load patterns due to Power Smart programs and continuous monitoring will be necessary.

## FORECAST UNCERTAINTY: RANGE OF ENERGY FORECASTS

A range of forecasts was projected around the probable load forecast. Uncertainties in the forecast are quantified by a probability distribution developed by combining the variabilities in the future levels of forecast drivers such as economic conditions, energy intensity, etc. The probability distribution of the gross load forecast has been defined by five values:

1. the 5th percentile (shown as "low" in Exhibit 3-1)
2. the 25th percentile
3. the probable forecast (which is close, but does not coincide exactly with the 50th percentile or median.
4. the 75th percentile
5. the 95th percentile (shown as "high" in Exhibit 3-1)

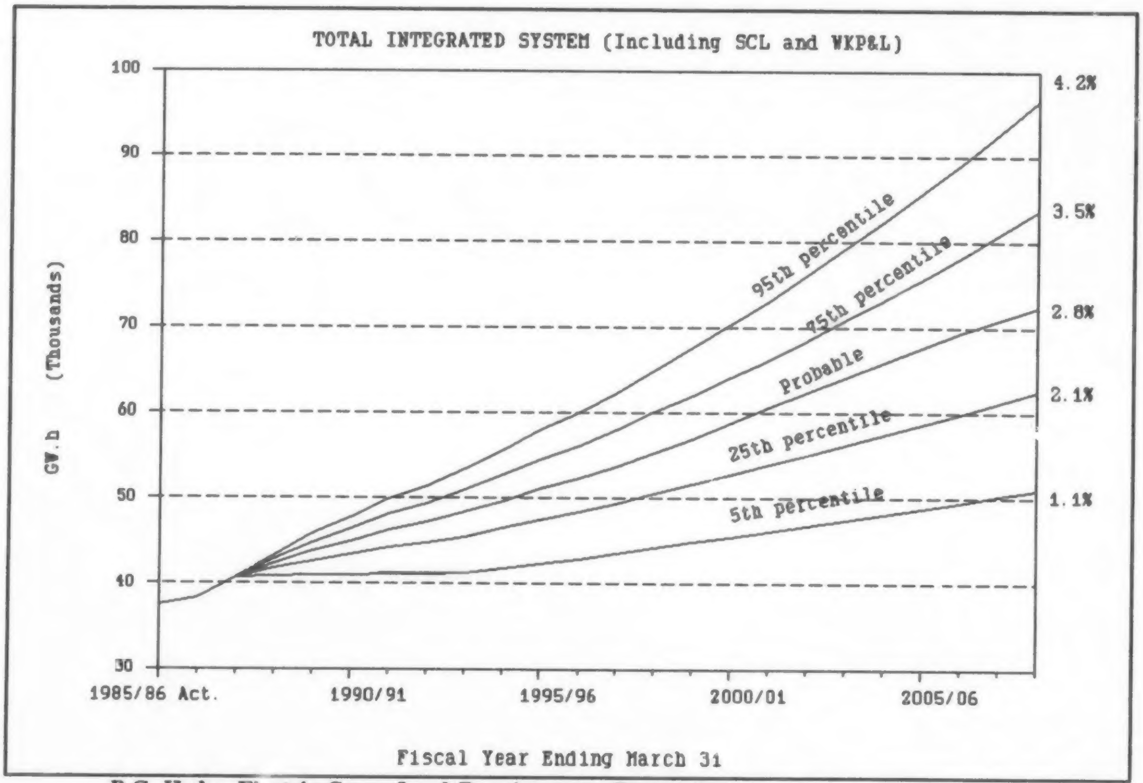
An example showing forecast values of gross load requirements ten and twenty years hence is included in the table below. Their interpretation is as follows (for the year 2008/09):

1. There is a 5% chance that load requirements will be below 50 960 GWh.
2. There is a 5% chance that load requirements will be above 96 570 GWh.
3. There is a 50% chance that actual demands will be between 62 520 GWh and 83 630 GWh.

**Gross Requirements**
(GWh)

| | 1998/99 | 2008/09 |
|---|---|---|
| 5th percentile | 44 260 | 50 960 |
| 25th percentile | 50 600 | 62 520 |
| probable | 55 060 | 72 090 |
| 75th percentile | 60 110 | 83 630 |
| 95th percentile | 65 080 | 96 570 |

The various forecasts for the integrated system (including SCL and WKP&L) are shown on the next page in graphic form.



B.C. Hydro Electric Gross Load Requirements Forecast

Exhibit III-1

## B.C. HYDRO PROBABLE GROSS LOAD REQUIREMENTS BY MAJOR SECTORS
(Including SCL & WKP&L)

| Fiscal Year | Residential Sales (GW.h) | Commercial Sales (GW.h) | Industrial Sales (GW.h) | Other Sales (GW.h) (1) | Total Sales (GW.h) (2) | Losses/ Accruals (GW.h) | TOTAL GROSS REQT'S. (GW.h) | Less Non-Integr. (GW.h) | Integr. TOTAL GROSS REQT'S. (GW.h) | System Peak (MW) |
|---|---|---|---|---|---|---|---|---|---|---|
| Actual | | | | | | | | | | |
| 1985/86 | 9793 | 8315 | 14571 | 456 | 33135 | 4292 | 37427 | 166 | 37261 | 6816 |
| 1986/87 | 9666 | 8678 | 15365 | 622 | 34331 | 3992 | 38306 | 167 | 38139 | 6577 |
| 1987/88 | 9902 | 9060 | 16427 | 679 | 36068 | 4725 | 40793 | 167 | 40626 | 7060 |
| Forecast | | | | | | | | | | |
| 1988/89 | 10298 | 9478 | 17010 | 705 | 37491 | 4830 | 42320 | 170 | 42150 | 7540 |
| 1989/90 | 10530 | 9688 | 17845 | 768 | 38831 | 4980 | 43810 | 180 | 43630 | 7640 |
| 1990/91 | 10763 | 9996 | 18379 | 751 | 39889 | 5110 | 45000 | 180 | 44820 | 7830 |
| 1991/92 | 10995 | 10296 | 18705 | 1036 | 41032 | 5270 | 46300 | 190 | 46110 | 8080 |
| 1992/93 | 11219 | 10646 | 18840 | 1088 | 41793 | 5390 | 47180 | 190 | 46990 | 8230 |
| 1993/94 | 11451 | 11029 | 19269 | 1135 | 42884 | 5540 | 48420 | 200 | 48220 | 8450 |
| 1994/95 | 11691 | 11445 | 19689 | 1196 | 44021 | 5690 | 49710 | 210 | 49500 | 8680 |
| 1995/96 | 11922 | 11896 | 20145 | 1261 | 45224 | 5850 | 51070 | 210 | 50860 | 8910 |
| 1996/97 | 12142 | 12362 | 20449 | 1333 | 46286 | 6000 | 52280 | 220 | 52060 | 9130 |
| 1997/98 | 12356 | 12850 | 20919 | 1390 | 47515 | 6170 | 53680 | 230 | 53450 | 9390 |
| 1998/99 | 12576 | 13355 | 21562 | 1455 | 48948 | 6350 | 55290 | 230 | 55060 | 9670 |
| Avg. Ann.% incr. | | | | | | | | | | |
| 11 years: | | | | | | | | | | |
| 87/88-98/99 | 2.2% | 3.6% | 2.5% | 7.2% | 2.8% | 2.7% | 2.8% | 3.0% | 2.8% | 2.9% |
| 1999/2000 | 12854 | 13873 | 22266 | 1454 | 50448 | 6540 | 56980 | 240 | 56740 | 9960 |
| 2000/01 | 13153 | 14409 | 22971 | 1524 | 52057 | 6740 | 58800 | 260 | 58540 | 10280 |
| 2001/02 | 13529 | 14963 | 23679 | 1591 | 53761 | 6960 | 60720 | 260 | 60460 | 10600 |
| 2002/03 | 13780 | 15532 | 24339 | 1658 | 55309 | 7160 | 62470 | 270 | 62200 | 10910 |
| 2003/04 | 14035 | 16112 | 25000 | 1732 | 56880 | 7370 | 64250 | 280 | 63970 | 11220 |
| 2004/05 | 14282 | 16708 | 25663 | 1806 | 58459 | 7570 | 66030 | 290 | 65740 | 11530 |
| 2005/06 | 14508 | 17315 | 26278 | 1875 | 59976 | 7770 | 67750 | 300 | 67450 | 11840 |
| 2006/07 | 14701 | 17931 | 26895 | 1931 | 61457 | 7960 | 69420 | 310 | 69110 | 12120 |
| 2007/08 | 14865 | 18547 | 27444 | 1985 | 62841 | 8140 | 70980 | 310 | 70670 | 12390 |
| 2008/09 | 15024 | 19165 | 27865 | 2039 | 64093 | 8320 | 72410 | 320 | 72090 | 12650 |
| Avg. Ann.% incr. | | | | | | | | | | |
| 10 years: | | | | | | | | | | |
| 98/99-08/09 | 1.8% | 3.7% | 2.6% | 3.4% | 2.7% | 2.7% | 2.7% | 3.4% | 2.7% | 2.7% |
| 21 years: | | | | | | | | | | |
| 87/88-08/09 | 2.0% | 3.6% | 2.5% | 5.4% | 2.8% | 2.7% | 2.8% | 3.1% | 2.8% | 2.8% |

Notes:

1. Inter-Utility transfers (including WKP&L) and firm export (including SCL).
2. Interruptible Marketing (E+) and Demand Side Management (DSM) programs not included.

# APPENDIX IV

# POWER SMART PROGRAMS

## RESIDENTIAL PROGRAMS

- Electric to Gas Water Heaters
- Domestic Water Heater Blankets
- Home Checkup
    - residential retrofit
    - Power Smart water heaters
    - appliance efficiency
    - refrigerator buy-back
- Residential Compact Fluorescent Lighting
- Quality Plus Homes
- Natural Gas– Fuel of Choice

## COMMERCIAL PROGRAMS

- Energy Efficient Lighting
    - energy saving lamp
    - fluorescent lamp reflector
    - incandescent lamp replacement
    - electrical controls
- New Building Design
- Building Retrofit

## INDUSTRIAL PROGRAMS

- High-efficiency Motor Rebate
- Adjustable Speed Drives
- High-efficiency Roadway Lighting
- Energy Efficient Industrial Lighting
- Efficient Compressed Air
- New Plant Energy Assessment
- Plant Retrofit (Audit)

## RESIDENTIAL PROGRAMS

### ELECTRIC TO GAS WATER HEATERS

**Objective:** To reduce future electric load growth by shifting existing electric domestic hot water heating applications to natural gas.

**Description:** Currently, about 9% of B. C. homeowners use natural gas space heating in combination with electric domestic hot water heating. Incentives will be offered to convert from electric to gas water heating.

**Strategy:** This program to be operated in cooperation with BC Gas Inc., will alert those customers who are requiring a replacement of their electric hot water tanks to the cost advantages of the gas option. Incentives for customers to switch will also be offered so that the conversion cost will be nearly the same as an electric replacement cost.

**Target Market:** The program will focus on single family dwellings, duplexes and mobile homes. It will be applied to all target market residences throughout B. C. where natural gas space heating and electric domestic hot water systems exist within the same household.

**Projected Impact** (preliminary):

| | |
|---|---|
| - twenty-year load reduction: | 3000 GWh |
| - maximum annual reduction: | 190 GWh |
| - total unit cost: | 0.05 to 0.15¢/kWh |

**Note:** A pilot program with Inland Natural Gas, Columbia Natural Gas, and Fort Nelson Gas is underway to convert mobile homeowners electric hot water tanks to natural gas. Plans are to launch the main program in the spring of 1989. Program with Pacific Northern ICG and Northwest Utilities, and parallel commercial projects are also being developed.

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### *DEFINITIONS*

**Twenty-Year Load Reduction:** The total of the program's load reductions from the program's start date to the year ending 31 March 2008.

**Maximum Annual Reduction:** The program's peak year load reduction between the program's start date and the year ending 31 March 2008.

**Total Unit Cost:** The total cost of the program, including both customer cost and Hydro's rebate and program costs, measured in ¢/kWh. When deciding upon the acceptability of a Power Smart program from the societal perspective, this value is compared to Hydro's marginal cost of new generation.

## DOMESTIC WATER HEATER BLANKETS

**Objective:** To reduce electric energy costs through increased tank insulation.

**Description:** Tank insulating blankets will be offered for homes that have electric water heating and are unlikely to be shifted to natural gas under the "Fuel of Choice" program. Blankets would not be applied to tanks already classified as energy-efficient.

**Strategy:** B. C. Hydro would purchase all necessary blankets and materials and hire contractors to install them. B. C. Hydro would advertise that this free service was available and collect applications.

**Target Market:** The program will be targeted at homes outside gas service areas. All electric homes which are unlikely to ever have gas service despite being in a gas service area will also be included.

**Projected Impact** (preliminary):

| | |
|---|---|
| - twenty-year load reduction: | 500 GWh |
| - maximum annual reduction: | 50 GWh |
| - total unit cost: | 1.5 to 2.5¢/kWh |

## HOME CHECKUP

Home check-up will provide a unified structure for residential Power Smart programs that reduce electrical energy use in residential buildings by increasing appliance efficiencies, upgrading the home envelope and switching fuel usage.

Three types of promotion will be used:

- Advertising to raise awareness of potential customer benefit and availability of Hydro assistance.
- Loans or incentives.
- Customer advisory staff and computer models to assist customers in quantifying benefits.

The program will include all homes in the B. C. Hydro service area with some components focused on electrically heated houses.

## RESIDENTIAL RETROFIT

**Objective:** To reduce base load electric consumption by increasing the insulation in existing electrically heated homes.

**Description:** The Residential Retrofit program will provide a loan to homeowners to improve the level of insulation and weatherization in existing housing. These will include items such as increased attic and wall insulation, double/triple glazed windows, and better caulking and sealing. This program is part of Home Checkup.

**Target Market:** The program will concentrate on all electrically heated homes in the B. C. Hydro service area.

**Projected Impact** (preliminary):

| | |
|---|---|
| - twenty-year load reduction: | 850 GWh |
| - maximum annual reduction: | 60 GWh |
| - total unit cost: | 1.0 to 2.0¢/kWh |

### POWER SMART WATER HEATERS

**Objective:** To change the average electric water heater from the current standard efficiency model to a high efficiency model with better insulation levels. The standby losses from the storage tanks represent wasted energy during the non-heating season.

**Description:** The program will eliminate the cost premium for the energy efficient tanks and promote the benefits of the new models to raise the market penetration for efficient tanks. This program is part of Home Checkup.

**Strategy:** As there are three major manufacturers who produce energy efficient models, there is no need for new technology. Customers purchasing electric water heaters will be encouraged to choose efficient ones through a program of labelling, promotions and incentives.

**Projected Impact** (preliminary):

| | |
|---|---|
| - twenty-year load reduction: | 250 GWh |
| - maximum annual reduction: | 25 GWh |
| - total unit cost: | 1.0 to 2.0¢/kWh |

### APPLIANCE EFFICIENCY PROGRAM

**Objective:** To promote the use of energy-efficient appliances.

**Description:** Energy-efficient appliances save up to 50% in energy costs over old, less-efficient models. To take advantage of this, the Energuide labelling program will be promoted and incentives on energy-efficient appliances may be provided. This program is part of Home Checkup.

**Strategy:** Energy efficiency will be promoted at the point of purchase.

**Target Market:** Any incentive offers will throughtout B. C. Hydro's service area.

**Projected Impact** (preliminary):

| | |
|---|---|
| - twenty-year load reduction: | 700 GWh |
| - maximum annual reduction: | 50 GWh |
| - total unit cost: | 2.0 to 3.0¢/kWh |

### REFRIGERATOR BUY-BACK PROGRAM

**Objective:** To reduce the penetration of less-efficient second refrigerators in households. Substantial load reduction and lower energy costs can be achieved by their removal from use.

**Description:** Free pick-up and disposal of old operating refrigerators plus a rebate. It is expected that 80-85% of picked up refrigerators would be disposed of, with the remainder being in satisfactory condition for re-use. This program is part of Home Checkup.

**Strategy:** This program is targeted at two groups of homeowners: those purchasing new refrigerators, and those who currently have two or more refrigerators.

**Projected Impact** (preliminary):

| | |
|---|---|
| - twenty-year load reduction: | 650 GWh |
| - maximum annual reduction: | 45 GWh |
| - total unit cost: | 1.0 to 2.0¢/kWh |

### RESIDENTIAL COMPACT FLUORESCENT LIGHTING

**Objective:** To reduce the electrical base load growth by encouraging the use of fluorescent lamps instead of the standard incandescent lamps. Energy savings can be up to 80%. In addition, smaller wattage "high tech" incandescent lamps will be investigated as possible replacements for flood and spot lamps. These have energy savings of 40 to 50%.

**Description:** This program will promote energy saving lamps to homeowners home builders, and landlords of apartments (for hallways) when they purchase replacement products.

**Strategy:** An information package will be made available to residential property managers on the benefits of compact fluorescent lighting for stairwells and halls. As well a program will promote the installation of compact fluorescent fixtures for new homes.

**Target Market:** Property managers and home builders throughout B. C. Hydro's service area.

**Projected Impact** (preliminary):

| | |
|---|---|
| - twenty-year load reduction: | 670 GWh |
| - maximum annual reduction: | 100 GWh |
| - total unit cost: | 0.5 to 1.0¢/kWh |

### QUALITY PLUS HOMES

**Objective:** To reduce future electric load growth by developing and promoting higher building standards for new homes that will use electricity for space and domestic hot water heating.

**Description:** The program will develop energy efficient new home construction recommendations that will take into consideration the climatic and fuel cost differences across the province.

**Strategy:** Three types of promotion will be used

- Training for the trades and real estate agents to increase their knowledge of building standards, lifecycle costs and benefits.
- Advertising and displays to raise consumer awareness of the benefits of improved building standards.
- Staff and computer advisory models will provide customer-specific quantification of benefits.

**Target Market:** Builders and developers of new homes throughout B. C. who are specially trained in the construction of energy-efficient homes. It will target homes not already shifted by the "Natural Gas — The Fuel of Choice" program.

**Projected Impact** (preliminary):

- twenty-year load reduction: 900 GWh
- maximum annual reduction: 65 GWh
- total unit cost: 6.0 to 8.0¢/kWh.

## NATURAL GAS — FUEL OF CHOICE

**Objective:** To reduce future electric load growth by shifting electric space heating and domestic hot water heating applications to natural gas.

**Description:** Builders and developers will be encouraged to use gas for heating applications.

**Strategy:** The cost advantages of natural gas over electricity for space and domestic water heating will be promoted. The issue of the technical barriers to widespread use of gas in row houses and apartments will be addressed. Presentations and training for builders, developers and real estate agents will be available. Customer advisory staff and computer models will provide individualized cost/benefit analysis for customers.

**Target Market:** Builders and developers of row houses, townhouses and apartments in the Lower Mainland will qualify.

**Projected Impact** (premliminary):

- twenty-year load reduction: 820 GWh
- maximum annual reduction: 115 GWh
- total unit cost: 0.15 to 0.3¢/kWh

## COMMERCIAL PROGRAMS

### ENERGY EFFICIENT LIGHTING

Recent developments in energy efficient lighting technologies have significant potential to reduce the energy consumed for lighting in commercial and institutional buildings. The energy efficient lighting program will serve as an umbrella to encourage the use of specific types of lighting technologies (initially energy saving fluorescent lamps, reflectors, alternatives to standard incandescent lamps and lighting controls).

Direct mail, direct customer contact, advertising in speciality trade magazines, and cooperation with trades allies will be used to reach the target market. Individual programs will target different segments of the market (commercial and institutional customers in B. C. Hydro's service area).

#### ENERGY SAVING LAMP

**Objective:** To reduce electrical load and load growth by encouraging the use of 34 watt energy saving 4-foot fluorescent lamps in place of the standard 40 watt lamps.

**Description:** Although energy saving lamps have a short payback (less than one year if replaced on burnout), the adoption of this product has been slow. This program intends to increase penetration of ES lamps by providing an incentive in the form of a rebate to reduce the initial purchase price and by starting an advertising/promotion/education campaign to increase public awareness of potential savings. This program is part of "energy efficient lighting".

**Strategy:** A pilot project has been completed to confirm customer response and to develop training and promotion documentation for the full program. Trade advertising, point of sale displays and direct information mailings will be used to raise customer awareness of the potential benefits. Seminars, trade training and on-site studies will increase understanding of technical considerations. A rebate will be used as an incentive to overcome reluctance to change from the "status quo".

**Target Market:** The primary market will be office buildings within B. C. Hydro's electric service area.

**Projected Impact** (preliminary):

| | |
|---|---|
| - twenty-year load reduction: | 2500 GWh |
| - maximum annual reduction: | 225 GWh |
| - total unit cost: | 0.1 to 0.5¢/kWh |

#### FLUORESCENT LAMP REFLECTOR

**Objective:** To reduce electrical load and load growth by encouraging the use of reflectors in fluorescent luminaires, permitting the removal of half the lamps and ballasts.

**Description:** Some work spaces are currently provided with more light than is required

Reflectors can be installed in the fixtures to increase their efficiency. This program is part of "energy efficient lighting".

**Strategy:** This program intends to increase the acceptance of the new technology by providing an incentive in the form of a rebate. It also plans to use advertising, promotion and education to increase the public awareness of potential savings.

**Target Markets:** Commercial and institutional buildings, predominantly large organizations.

**Projected Impact** (preliminary)

| | |
|---|---|
| - twenty-year load reduction: | 2500 GWh |
| - maximum annual reduction: | 200 GWh |
| - total unit cost: | 2.0 to 2.5¢/kWh |

This load reduction takes into account a reduction in savings obtained with the ES lamp program.

### INCANDESCENT LAMP REPLACEMENT

**Objective:** To reduce electrical load and load growth by promoting use of more efficient lamps.

**Description:** This program will encourage the use of compact fluorescent lamps instead of standard incandescent lamps, with energy savings of 80%. The use of smaller wattage "high-tech" incandescent lamps will also be promoted as replacements for flood and spot lamps, typically used in retail merchandising. These have an energy savings of 40 to 50%. This program is part of "energy efficient lighting".

**Strategy:** Seminars, trade training, on-site studies will be used to raise customer awareness about the benefits obtained from the use of lower wattage lighting sources. A rebate will be used as an incentive to overcome the "status quo" and to cover changes to luminaires resulting from accepting reduced energy sources.

**Target Markets:** This program is targeted at small commercial and institutional consumers, throughout all B. C. Hydro electric service areas, who will not participate in the energy saving lamps or reflector programs.

**Projected Impact** (preliminary):

| | |
|---|---|
| - twenty-year load reduction: | 2700 GWh |
| - maximum annual reduction: | 200 GWh |
| - total unit cost: | 1.0 to 2.0¢/kWh |

### ELECTRICAL CONTROLS

**Objective:** To reduce electrical load and load growth by encouraging installation and use of control systems.

**Description:** The Electrical Control program is intended to interface with other Power Smart programs to increase energy savings by providing the facilities to enable energy consuming systems to be turned down or switched off at any time when some or none of the energy is needed. This program is part of "Energy efficient lighting".

**Strategy:** This program will investigate automatic and manual energy control devices. Training seminars, information literature and education at all levels will be provided to create awareness and identify the financial benefits for users. Rebates prorated to savings, materials and labour for demonstration projects, tabulated data on usage of energy and education packages will also be provided.

**Target Market:** All areas where Power Smart programs are initiated.

**Projected Impact** (preliminary)

| | |
|---|---|
| - twenty-year load reduction: | 1450 GWh |
| - maximum annual reduction: | 100 GWh |
| - total unit cost: | 1.0 to 2.0¢/kWh |

## NEW BUILDING DESIGN

**Objective:** To promote energy-efficiency design and construction in new commercial and institutional buildings.

**Description:** This is a ten-year program which will offer technical and financial assistance in evaluating and installing energy efficient design alternatives for new building projects.

**Strategy:** Technical and financial assistance will be provided to architects, engineers and consultants, to identify and evaluate energy-efficient alternatives. Where applicable, financial assistance will be provided to developers and building owners to assist in the implementation.

**Target Market:** All new commercial and institutional construction projects within B. C. Hydro's area.

**Projected Impact** (preliminary):

| | |
|---|---|
| - twenty-year load reduction: | 1850 GWh |
| - maximum annual reduction: | 200 GWh |
| - total unit cost: | 2.0 to 3.0¢/kWh |

## BUILDING RETROFIT

**Objective:** To promote the installation of energy efficient equipment and technologies in existing buildings.

**Description:** This is a ten-year program which will offer technical/ engineering audits and retrofit incentives to all existing commercial and institutional customers in

B. C. Hydro's service area.

**Strategy:** B. C. Hydro will assist the building owners in identifying energy conservation measures and quantifying potential savings in the following areas:

- building HVAC system controls;
- building envelope (e.g. insulation, solar film, etc.);
- heat recovery equipment;
- mechanical system upgrade;
- lighting.

**Target Market:** Mainly commercial and institutional buildings with high energy consumption levels. The initial phase of the program will target electrically heated buildings.

**Projected Impact** (preliminary):

| | |
|---|---|
| - twenty-year load reduction: | 1400 GWh |
| - maximum annual reduction: | 100 GWh |
| - total unit cost: | 3.0 to 4.0¢/kWh |

## INDUSTRIAL PROGRAMS

### HIGH-EFFICIENCY MOTOR REBATE

**Objective:** To reduce electrical energy use by encouraging the use of high-efficiency motors.

**Description:** Electric motors use approximately 65% of the electricity consumption for commercial and industrial customers. This program is designed to promote the use of high-efficiency motors in new installations and replacement of nonfunctioning equipment. High-efficiency motors are 3% to 10% more efficient than standard models.

**Strategy:** Rebates will be used to make the high-efficiency motors more attractive. (Currently they are at a 20%-30% premium). The program will use direct market research and secondary data to size the target market, and customer decision-making criteria. It will also use promotion and education to raise customer awareness of potential benefits, supported by trade advertising, and direct mail. Direct customer contact, supported by computer analytical models, will be used to quantify specific customer benefits.

**Projected Impact** (preliminary):

| | |
|---|---|
| - twenty-year load reduction: | 3355 GWh |
| - maximum annual reduction: | 370 GWh |
| - total unit cost: | 0.6 to 1.0¢/kWh |

**Note:** The program has been in effect since the end of June 1988 and was publicly launched in October, 1988.

## ADJUSTABLE SPEED DRIVES

**Objective:** To promote the use of adjustable speed drives to industrial customers to more efficiently control the mechanical power used to operate machinery.

**Description:** Economic and engineering assistance would be offered by B. C. Hydro to convert existing throttling control systems to adjustable speed drives or to design new adjustable speed drives. The program is still in the market research stage. Information will be available in Spring 1989.

**Target Market:** Large industrial customers in B. C. Hydro's service area.

**Projected Impact** (preliminary):

| | |
|---|---|
| - Twenty-year Load Reduction: | 4430 GWh. |
| - Maximum Annual reduction: | 370 GWh. |
| - Total unit cost: | N/A |

## HIGH-EFFICIENCY ROADWAY LIGHTING

**Objective:** To reduce electrical load and load growth by encouraging conversion of street lighting to efficient systems.

**Description:** The program will encourage conversion of mercury vapour, fluorescent and incandescent lighting to high pressure sodium lighting. This will lead to a 50% to 75% energy reduction per luminaire for equal lighting output.

**Strategy:** The B. C. Hydro Roadway Lighting program will:

- Confirm numbers of luminaires of each type, update B. C. Hydro data on locations and use.
- Prepare seminars and direct mail data for end users.
- Provide rebates to overcome reluctance to change from existing specifications to energy saving systems.
- Change specifications for street lighting to use more efficient technologies.

**Target Markets:** All inefficient street lighting systems in B. C. Hydro's service area including cities, corporations, districts and electric utilities.

**Projected Impact** (preliminary):

| | |
|---|---|
| - twenty-year load reduction: | 1400 GWh |
| - maximum annual reduction: | 85 GWh |
| - total unit cost: | 0.5 to 2.5¢/kWh |

## ENERGY EFFICIENT INDUSTRIAL LIGHTING

**Objective:** To reduce electrical load and load growth by encouraging the use of high pressure sodium and metal halide lighting instead of mercury vapour and incandescent lighting in industrial locations. These systems are 30-50% more efficient.

**Description:** The program will involve encouraging industrial plant owners and operators to improve the efficiency of their existing lighting systems.

**Strategy:** The program will:

- Provide information on benefits to businesses from better lighting through seminars, direct contact with the trade, selected advertising and computer analysis programs.
- Provide financing or other incentives where necessary.
- Visit plants to identify areas for improvement.

**Projected Impact** (preliminary):

| | |
|---|---|
| - twenty-year load reduction: | 1800 GWh |
| - maximum annual reduction: | 180 GWh |
| - total unit cost: | 0.8 to 1.6¢/kWh |

## EFFICIENT COMPRESSED AIR

**Objective:** To reduce the energy wasted in industrial plants due to losses in pressurized air piping systems. Is is estimated that 15% of the energy used in these plants is wasted due to leaks in the equipment.

**Description:** The Compressed Air program will involve the use of contractors to perform tests of industrial compressed air systems to indicate the amount of leaks, their cost and a reasonable efficiency target. A pilot program is under way to determine the effectiveness of a leak testing procedure.

**Strategy:** Contractors will be funded to perform tests of major industrial systems. Ongoing follow-up should encourage customers to perform annual tests and maintenance of their compressed air systems.

**Target Markets:** The program will target the largest industrial compressed air users.

**Projected Impact** (preliminary):

| | |
|---|---|
| - twenty-year load reduction: | 1035 GWh |
| - maximum annual reduction: | 60 GWh |
| - total unit cost: | 1.0 to 2.0¢/kWh |

## NEW PLANT ENERGY ASSESSMENT

**Objective:** To reduce future load growth through efficient energy use in new industrial facilities.

**Description:** The program will have B. C. Hydro sponsor engineering studies to assess the energy options for construction of new projects.

**Strategy:** Prior to new construction of facilities, B. C. Hydro will pay for extra engineering assistance to analyze the design plans with respect to energy consumption, energy use options available and their economics. The message will be delivered through direct contact at various organizational levels.

**Target Markets:** The program will primarily target the largest industrial consulting firms. The secondary target will be 600 of B. C.'s largest industrial companies.

**Projected Impact** (preliminary):

- twenty-year load reduction: 535 GWh
- maximum annual reduction: 35 GWh
- total unit cost: 1.0 to 2.0¢/kWh

## PLANT RETROFIT (AUDIT)

**Objective:** To reduce current and future loads by improving energy efficienty of industrial processes.

**Description:** B. C. industrial plants are rated in some categories as less energy efficient than their international competition. This program is designed to encourage companies to modify their existing plant systems, where economical, in order to reduce their long-term energy costs.

**Strategy:** B. C. Hydro will pay for engineering studies of industrial plants to assess their present energy use and to determine alternatives available for efficiency improvement. It will include mechanical drives, equipment loading, piping systems and lubrication procedures to reduce friction losses. Incentive funding to assist in recommended plant modifications may be provided by B. C. Hydro.

**Target Markets:** Large industrial customers would be initially targeted. Engineering studies would be concentrated on areas where process efficiency and energy utilization efficiency would be improved at the same time.

**Projected Impact** (preliminary):

- twenty-year load reduction: 2210 GWh
- peak year reduction: 150 GWh
- total unit cost: 1.0 to 2.0¢/kWh

# APPENDIX V

# RESOURCE SMART AND NEW GENERATION PROJECTS

This Appendix summarizes the status of selected potential generation projects currently under consideration by B. C. Hydro. Capital cost figures are in October 1988 uninflated dollars, unless otherwise indicated, and exclude interest during construction (IDC) and corporate overhead. However, uniform energy costs for all projects do include IDC and corporate overhead.

## RESOURCE SMART

### (a) Keenleyside

Keenleyside dam was constructed as a storage project to provide flow regulation under terms of the Columbia River Treaty. The Keenleyside powerplant project would consist of a powerhouse on the north bank of the river adjacent to the existing dam. The powerhouse would contain three 80 MW units.

If the Murphy Creek project were to be constructed soon (within a few years) after the Keenleyside powerplant project, the Keenleyside design may be modified to three 60 MW units to allow for reduction of capacity due to operation at higher tailwater levels caused by the Murphy Creek project.

| | | |
|---|---|---|
| Peak Capacity | 240 MW | 180 MW |
| Firm Energy | 1030 GWh | 910 GWh |
| Average Energy | 1140 GWh | 940 GWh |

Transmission would link the generating station to the main B. C. Hydro grid at the Selkirk substation.

The total capital cost would be $370 million including transmission for the 240 MW plant or $339 million including transmission for the 180 MW plant. Equivalent uniform energy cost would be about 3.0¢/kWh for the 240 MW plant and about 3.3¢/kWh for the 180 MW plant at a 6% net discount rate.

Engineering preliminary design has been completed for the 180 MW alternative, and has been adjusted to include cost estimates for the 240 MW alternative. When project studies were deferred in 1984, environmental and socio- economic studies had been completed to the level believed to be sufficient to support an application for an Energy Project Certificate.

As part of B. C. Hydro's contingency planning for uncertain future electricity demand, a consultant has been engaged to update the Keenleyside Project studies and to carry out further studies needed to bring the project to a state of preparedness for an Energy Project Certificate application.

The Keenleyside project is not expected to cause any significant environmental impacts and would provide a positive stimulus to employment in the area which has an experienced construction labour force.

The project could be brought into service as early as 1997.

## (b) Brilliant Expansion

The existing 116 MW Brilliant project, owned by Cominco Ltd., is located on the Kootenay River 3 km from its confluence with the Columbia River. Additional flow regulation on the Kootenay River, provided under terms of the Columbia River Treaty subsequent to construction of the Brilliant project, has created an opportunity for additional generation at Brilliant.

Based on a one-year overview study by B. C. Hydro, a 150 MW capacity powerplant expansion has been recommended for further studies. The expansion project would use water which is in excess of flows authorized by the Water Licence held by Cominco Ltd.

| | |
|---|---|
| Peak Capacity | 150 MW |
| Firm Energy | 449 GWh |
| Average Energy | 584 GWh |

Transmission would link the expansion powerplant to the main B. C. Hydro grid at the Selkirk Substation.

The total estimated capital cost is $226 million, including transmission. Equivalent uniform energy cost would be about 3.5¢/kWh at a 6% net discount rate.

There appear to be no major environmental concerns. The project would provide a positive stimulus to employment in the area, which has an experienced construction labour force.

The project could be brought into service as early as 1998.

## (c) Waneta Expansion

The existing 360 MW Waneta project, owned by Cominco Ltd. is located on the Pend d'Oreille River 0.5 km from its confluence with the Columbia River. Additional flow regulation now available on the Pend d'Oreille River and the hydraulic imbalance between Waneta and upstream plants have created an opportunity for additional generation at Waneta.

Based on a one-year overview study by B. C. Hydro, a 380 MW capacity powerplant expansion has been recommended for further studies. The expansion project would use water which is in excess of flows authorized by the Water Licence held by Cominco Ltd.

| | |
|---|---|
| Peak Capacity | 380 MW |
| Firm Energy | 527 GWh |
| Average Energy | 946 GWh |

Transmission would link the expansion power plant to the main B. C. Hydro grid at the Selkirk Substation.

The total estimated capital cost is $275 million including transmission. Equivalent uniform energy cost would be about $3.2¢/kWh at a 6% discount rate.

There appear to be no major environmental concerns. The project would provide a positive stimulus to employment in the area, which has an experienced construction labour force.

The project could be brought into service as early as 1997.

### (d) Seven Mile — Unit 4

Addition of unit 4 would complete development of the Seven Mile project on the Pend-d'Oreille River in southwestern B. C. The project would consist of the addition of the fourth unit to increase the nameplate capacity of the plant to 810 MW.

| | |
|---|---|
| Peak Capacity | 202.5 MW |
| Firm Energy | 140 GWh |
| Average Energy | 290 GWh |

The total capital cost would be about $72 million. Equivalent uniform energy cost would be about 2.7¢/kWh at a 6% net discount rate.

Total construction time would be about 4 years. There would be no environmental effects since reservoir levels would not be altered.

### (e) Barnes Creek Diversion

Diversion of Barnes Creek into Whatshan Lake would result in an additional 47 GWh/year of energy generation at the Whatshan Generating Station, located on the shore of Lower Arrow Lake. No increase in plant capacity at Whatshan would be required.

The diversion project would consist of a concrete weir across Barnes Creek, with a gated intake structure leading via a tunnel and an improved natural channel to Whatshan Lake.

The total estimated capital cost is $9.0 million. Equivalent uniform energy cost would be 1.7¢/kWh at a 6% net discount rate.

The main environmental impact would be on fish in Barnes Creek downstream from the diversion. Potential measures for mitigating these impacts have been identified.

Following a one-year overview assessment, an application for a Water Licence was submitted in 1988. Subject to receiving the licence in 1989, the project could be brought into service as early as 1992.

### (f) Duncan Dam

Duncan dam was constructed as a storage project to provide flow regulation under terms of the Columbia River Treaty. The Duncan power plant project would involve construction of a single unit, 25 MW powerhouse at the outlet of one of the two existing discharge tunnels, located in the north abutment of the dam.

The project would have an average annual generating capability of 105 GWh.

Transmission would link the generating station to the main B. C. Hydro grid either at Vernon Terminal Substation or, if wheeling is available through West Kootenay Power and Cominco facilities, at the Kootenay Canal Generating Station.

The total estimated capital cost is $53.6 million, including transmission. Equivalent uniform energy cost would be 4.1¢/kWh at a 6% net discount rate, including an allowance for wheeling costs through the West Kootenay/Cominco system.

A one-year overview study has been completed. There appear to be no major environmental concerns.

The project could be brought into service as early as 1993.

### (g) Falls River Redevelopment

Redevelopment of the existing Falls River project near Prince Rupert would include rehabilitation of the existing dam and replacement of the existing 6.9 MW, 2-unit powerhouse and penstocks with a new 22 MW single unit powerhouse and penstock.

The project would have an average annual generating capability of 91 GWh.

The existing transmission line to Rupert Substation, with minor line relocation to the new powerhouse, would be adequate for the increased generating capacity.

The total estimated capital cost is $36.8 million. Equivalent unit energy cost would be about 3.9¢/kWh at a 6% net discount rate.

Previous studies identified a possible impact on salmon, which may require mitigative measures.

A Certificate of Public Convenience and Necessity for the redevelopment project was granted to B. C. Hydro in 1981. However, the work was deferred due to the anticipated energy surplus and higher than expected tender bids. Temporary rehabilitation measures to maintain the facilities in a safe operating condition for at least a further eight years were completed in 1983.

A review and updating of the redevelopment project is scheduled for 1989/90. The project could be brought into service as early as 1994.

Note: Although the uniform energy costs for Duncan and Falls River are somewhat higher than the current long-term value of energy, these projects remain attractive when other aspects are taken into consideration, such as minimal environmental impacts.

## NEW GENERATION PROJECTS

### HYDROELECTRIC

### (a) Peace Site C

The project would be located on the Peace River, 7 km upstream of Fort St. John. It would comprise a 60 m high earthfill dam and a powerhouse with six 150 MW units. An 80 km long reservoir would extend upstream to Peace Canyon dam.

| | |
|---|---|
| Peak Capacity | 900 MW |
| Firm Energy | 4570 GWh |
| Average Energy | 4710 GWh |

The total capital cost would be $1739 million including transmission. Equivalent uniform energy cost would be about 3.6¢/kWh at a 6% net discount rate.

Engineering preliminary design has been completed. Hearings for an Energy Project Certificate were concluded in November 1982. No overriding engineering or environmental concerns were identified, but B. C. Hydro will be required to submit a new application, with justification of need for the project, before construction can commence.

As part of B. C. Hydro's contingency planning for uncertain future electricity demand, a consultant has been engaged to update the Peace Site C Project studies and to carry out further studies needed to bring the project to a state of preparedness for an Energy Project Certificate re-application.

The reservoir would flood potential agricultural land now within the Agricultural Land Reserve and would require the relocation of some families in the project area. Trapping and hunting by native people would be adversely affected by access roads along the proposed transmission line route.

The project could be brought into service as early as 1997.

### (b) Murphy Creek

The Murphy Creek project would be located on the Columbia River 3 km upstream from Trail. This low-head development would consist of an earthfill dam with a powerhouse on the west bank containing five 55 MW units. It would be linked to the main B. C. Hydro transmission grid with a short loop to the Keenleyside-Selkirk transmission line.

| | |
|---|---|
| Peak Capacity | 275 MW |
| Firm Energy | 1480 GWh (following a 180 MW Keenleyside)<br>1380 GWh (following a 240 MW Keenleyside) |
| Average Energy | 1620 GWh (following a 180 MW Keenleyside)<br>1450 GWh (following a 240 MW Keenleyside) |

The energy figures shown above are net amounts after allowances for the losses caused by higher tailwater levels at the existing Brilliant powerplant and at the proposed Keenleyside powerplant.

The total capital cost would be $723 million including transmission. Equivalent uniform energy cost would be about 4.0¢/kWh at a 6% net discount rate, if it followed a 180 MW Keenleyside project, or about 4.4¢/kWh at a 6% net discount rate, if it followed a 240 MW Keenleyside project.

Engineering preliminary design studies for Murphy Creek have been completed. When project studies were deferred in 1984, environmental and socio-economic studies had been completed to a level believed to be sufficient to support an application for an Energy Project Certificate.

It would be necessary to relocate about 70 households adjacent to the proposed reservoir, and some sections of highway and railway would have to be relocated. There would also be a significant impact upon mule deer and the Kokanee fishery along this portion of the Columbia River. From a socio-economic viewpoint, this project would provide a positive stimulus to employment in the area which has an experienced resident construction labour force.

The project could be bought into service as early as 1999.

### (c) Stikine-Iskut

The 2900 MW Stikine-Iskut development would harness the hydroelectric potential of a major undeveloped river basin in northwestern British Columbia. The four hydroelectric sites being considered for power development are: Stikine Canyon and Tanzilla on the Stikine River; Iskut Canyon on the Iskut River, and a site on More Creek just upstream of its confluence with the Iskut River. In addition, diversion of the headwaters of Forrest Kerr Creek into the headwaters of More Creek is proposed in order to increase the potential of the More Creek site.

| | |
|---|---|
| Peak Capacity | 2 900 MW |
| Firm Energy | 13 130 GWh |
| Average Energy | 15 570 GWh |

The total capital cost of the development would be $6439 million including transmission. Equivalent uniform energy cost would be about 5.0¢/kWh at a 6% net discount rate.

Engineering preliminary design studies for all projects were partially complete when work on the development was suspended in 1983. An Interim Assessment report was prepared in 1983 on the status of all work to date.

Major environmental impacts include: possible effects of flow regulation on migrating and spawning salmon; development in and partial flooding of the Grand Canyon of the Stikine; effects of flow regulation on the Stikine estuary within Alaska; impacts on the communities of Telegraph Creek, Iskut and Dease Lake caused by the introduction of a large work force in the area; and impacts of transmission lines, including access roads, upon previously inaccessible fisheries and wildlife habitats and scenic areas.

The Stikine River Recreation Area, established in March 1987, includes the areas required for potential future hydroelectric reservoirs on the Stikine River. The recreation area designation enables the Province to manage the wilderness, scenic and recreational values of the upper Stikine River and surrounding lands until a decision is taken on hydroelectric development.

The first project in the development could be brought into service as early as 2003.

### (d) Liard

The Liard development would initially consist of two projects in an undeveloped river basin in northern British Columbia: the 2490 MW Devils Gorge storage and power project, 25 km downstream from the Liard River Hotsprings Provincial Park; and the 700 MW Hell Gate power project, 40 km downstream from Devils Gorge. A future development at Beavercrow, 85 km downstream from Hell Gate, could follow and would provide an additional 1128 MW of capacity and 6190 GWh/year of firm energy.

| | |
|---|---|
| Peak Capacity | 3 190 MW |
| Firm Energy | 16 730 GWh |
| Average Energy | 18 380 GWh |

The total capital cost for the two-project arrangement would be $7044 million including transmission. Equivalent uniform energy cost would be about 4.7¢/kWh at a 6% net discount rate. With Beavercrow, the three-project arrangement would have total capital cost of $11417 million including transmission and would have an equivalent uniform energy cost of about 5.4¢/kWh at a 6% net discount rate.

Engineering feasibility studies have been completed for the Devils Gorge and Beavercrow projects. A limited one-year feasibility study for the Hell Gate project and a one-year preliminary design study on the Devils Gorge project were completed prior to 1982 when all studies were suspended. Interim engineering and environmental reports and a summary report were prepared on the work completed to date. Preliminary transmission system and corridor selection studies were in progress when the program was terminated.

Flooding of the Liard River Hot Springs and the Muddy River Indian Reserve, as well as relocation of portions of the Alaska Highway and five settlements along the highway are major environmental concerns. Native people's traditional hunting areas would receive an adverse impact from access roads into currently inaccessible areas. Effects of flow regulation could extend downstream as far as the Mackenzie Delta.

The development could be brought into service as early as 2008.

### (e) Homathko

The Homathko development would initially consist of a two-powerplant (710 MW) scheme in an undeveloped river basin in the Coastal Mountains, with a 290 MW power project on Mosley Creek and a 420 MW power project at Waddington Canyon on the Homathko River. Transmission from the project would feed into central British Columbia and to Vancouver Island. A storage dam on Tatlayoko Lake with a dam and a 185 MW powerplant on the Homathko River at Nude Canyon could be constructed later.

| | 2 Projects | 3 Projects |
|---|---|---|
| Peak Capacity | 710 MW | 895 MW |
| Firm Energy | 3500 GWh | 4440 GWh |
| Average Energy | 3430 GWh | 4360 GWh |

The total capital cost for the two-project scheme would be $1844 million including transmission. Equivalent uniform energy cost would be about 5.4¢/kWh at a 6% net discount rate. The three-project scheme would have a total capital cost of $2421 million including transmission. Equivalent uniform energy cost would be about 5.5¢/kWh at a 6% net discount rate.

Engineering, properties and environmental overview studies and one year of preparation for feasibility studies have been completed. Two years of a limited feasibility study have also been completed.

The development would produce seasonal changes in the Homathko River streamflow, which could affect salmonids spawning in the lower reaches of the river. Impacts on wildlife populations would occur due to increased access into the area. Environmental impacts associated with the transmission lines have not been determined.

The development could be brought into service as early as 2002.

## THERMAL

### (a) Hat Creek

This project would be located in the Hat Creek valley, about 80 km west of Kamloops. It would have two basic components, a mine and a powerplant, both located at the north end of the valley. Coal would be mined in a large open pit mine and transported by conveyor to the powerplant located 4 km to the northeast and 500 m above the mine. Three different project arrangements have been studied: a 2000 MW (net) plant; a 720 MW (net) plant; and a 204 MW (net) plant. For the 2000 and 720 MW plants, steam would be condensed by evaporative cooling towers, using water from the Thompson River for makeup. The 204 MW plant would use Hat Creek water for cooling. Flue-gas treatment would remove about 90% of the sulphur dioxide.

| | | | |
|---|---|---|---|
| Peak Capacity | 2 000 MW | 720 MW | 204 MW |
| Firm Energy | 13 140 GWh | 5 050 GWh | 1 340 GWh |

The total capital cost of the 2000 MW alternative would be $3020 million including transmission. Equivalent uniform energy cost would be about 3.7¢/kWh at a 6% net discount rate. For the 720 MW alternative the total capital cost would be $1370 million including transmission. Equivalent uniform energy cost would be about 4.3¢/kWh at a 6% net discount rate. The cost estimates for the 2000 MW and 700 MW alternatives are based on estimates by Shawinigan-Integ for the powerplant with 52% scrubbing of sulphur dioxide and Fitzpatrick Mining Consultants for the mine. New estimates for the 204 MW alternative were not prepared.

Preliminary engineering, detailed environmental studies and an environmental impact statement have been completed for the 2000 MW project. Some property has been acquired in the Hat Creek valley and coal licences covering the whole valley are being maintained.

Emissions from the 2000 MW Plant are not expected to affect public health adversely. There is potential for injury only to the most sensitive vegetation species in the vicinity of the project. Runoff and seepage from mine waste disposal and coal storage would not be discharged and surface water would only be discharged after treatment for sediment control. Increased water temperature in the Hat Creek downstream of the plant might affect some aquatic life. Area alienated would total less than 2500 ha of range and crop land. Over 3200 construction and operating employees would be needed during the peak of construction and over 1200 permanent new jobs would be created. The scale of the project would have some impact on local housing, services and facilities and on native Indian bands who live near the development.

For the 700 MW plant it can be assumed that the impacts would be similar to the 2000 MW plant, but on a reduced scale.

For the 204 MW plant, most impacts would be reduced further. There would be no Thompson River intake or pipeline; instead, water would be taken from Hat Creek and the impacts downstream would, therefore, increase, but overall there would be less impact.

The 2000 MW project could be brought into service as early as 1998.

## OTHER POTENTIAL PROJECTS

Other projects which Hydro has studied in the past are listed below. The level of knowledge of these projects generally is lower than the preceding projects, or their costs are too high to include in alternative plans at this time.

| **Project** | **Capacity** (MW) | **Firm Energy** (GWh) | **Average Energy** (GWh) |
|---|---|---|---|
| **Hydroelectric** | | | |
| Border | 250 | 1510 | 1610 |
| Elaho | 340 | 1560 | 2100 |
| McGregor Lower Canyon | 360 | 1720 | 1950 |
| **Thermal and Alternative** | | | |
| East Kootenay Thermal | 600 | 3940 | |
| Combustion Turbine-Simple Cycle | 636 | 3300 | |
| Solar-Power Tower | 100 | 200 | |
| Wind Farm | 16 | 30 | |

## GENERATION STUDIES

The following generation project surveys and investigations are planned for 1989/90, to maintain an inventory of resource options for possible future development:

1. **Preparatory Activities — Peace Site C and Keenleyside**

   Engineering, environmental and other activities required to bring the Peace Site C and Keenleyside projects to a state of readiness for final licensing.

2. **Resource Smart Program — Phase II**

   Detailed studies to assess the potential for increasing the energy output of existing B. C. Hydro hydroelectric projects which were identified in the Phase I inventory study.

3. **Barnes Creek Diversion Study**

   Preliminary design studies for diversion of Barnes Creek into Whatshan Reservoir as a source of additional energy. This work is contingent upon receipt of Water Licence—application was submitted in July 1988.

4. **Williston Reservoir Raising Studies**

   Completion of studies undertaken in 1988 to obtain new aerial photography, determine the area that would be flooded by raising the maximum normal operating level of the reservoir, and reassess the project economics.

5. **Elk River Development Studies**

   Completion of engineering and environmental overview studies undertaken in 1988 to assess the hydroelectric potential of the Elk River downstream from Elko Generating Station.

6. **Brilliant Expansion Studies**

   Completion of engineering and environmental studies to assess the potential for installing additional generating capacity at the existing Brilliant Powerplant, owned by Cominco Ltd. The study will include assessment of possible joint redevelopment of the site by B. C. Hydro and Cominco.

7. **Waneta Expansion Studies**

   Completion of engineering and environmental studies to assess the potential for installing additional generating capacity at the existing Waneta Powerplant, owned by Cominco Ltd. The study will include assessment of possible joint redevelopment of the site by B. C. Hydro and Cominco.

8. **Border Project Studies**

Overview study to assess the hydroelectric potential of the Border site on the Columbia River near the confluence of the Pend d'Oreille River, including a limited foundation drilling program.

9. **Columbia River Studies Summary**

Summarize the results of studies to date on the Keenleyside, Murphy Creek, Seven Mile Unit 4, Duncan, Brilliant and Waneta Expansions and Border projects, to define the most desirable project configuration and sequence for completing the lower Columbia River development.

10. **Hydrometric Remobilization**

Operation of streamflow and climate data collection facilities which have been re-established in the Stikine-Iskut, Homathko and Liard River basins, to develop long-term hydrological records for future project studies.

11. **Hydrological Investigations**

Ongoing hydrological studies of potential hydroelectric resources, liaison with government data collection agencies, and monitoring of Peace River ice conditions to minimize adverse effects on generation and on communities downstream of Bennett Dam.

12. **Homathko Watershed Model**

Development of a watershed runoff model for the Homathko River basin to provide synthesized flow data at the project sites for use in resource planning studies.

13. **Kemano Hydrometric Network**

Design, installation and ongoing operation of a hydrological data collection network required for operation of the Nechako Reservoir, in conjunction with Alcan Ltd.

14. **Glacier Mass Balance Studies**

A two-year program of remote sensing studies to monitor glacier mass balance changes in the Iskut and Homathko River basins.

15. **Geotechnical Investigations**

Re-establish the seismic array to monitor earthquake activity in the Stikine-Iskut River basin, and resume geotechnical monitoring and inspection programs.

16. **Seismic Studies — UBC**

Provide financial support for ongoing studies at University of British Columbia to improve location accuracy and estimates of the depth of earthquakes in southwestern B. C., to delineate active fault systems, to permit estimates of their level of activity and to examine the attenuation of seismic ground motion with distance.

### 17. Hat Creek Maintenance, Monitoring and Reclamation

Ongoing activities such as site inspection, routine maintenance, site reclamation and periodic reporting, in conformance with provincial statute, to maintain the coal licences at Hat Creek.

# APPENDIX VI

# PURCHASE OF ELECTRICITY SUPPLY AND LOAD DISPLACEMENT

## PURCHASING CONSIDERATIONS

This document describes B. C. Hydro's purchase policy, the planned Request for Proposal (RFP) process, purchase prices, and general technical requirements.

The major load centres in B.C. are essentially the Lower Mainland area and Vancouver Island. Because of constraints to transmission from the main generation sites in the interior, projects that can supply these areas directly will tend to be more attractive.

### PURCHASE OF ELECTRICITY

B. C. Hydro will purchase electricity for the integrated system in increments greater than 5MW, when new generation is required, provided that the quality is acceptable and the cost to B. C. Hydro is lower than the cost of other alternatives available, including any costs associated with modifying B. C. Hydro's facilities in order to accept these deliveries of electricity.

These purchases can be from a producer under one of the following categories:

a. directly from IPP's (Independent Power Producers)
b. surplus electricity from self-generators, including cogeneration

B. C. Hydro will also consider wheeling of electricity from an IPP to the IPP's customer, where it is for incremental load within the B. C. Hydro service area, and where sufficient capacity exists, and is likely to continue to exist, in the B. C. Hydro transmission system.

To pursue electricity purchases and assist IPPs, B. C. Hydro will:

a) Seek electricity supply proposals as new generation is required for the integrated system.

b) Purchase electricity in increments greater than 5MW from producers wishing to supply the integrated system, following a public RFP process, at rates and other terms based on competitive negotiations.

c) Identify technical requirements and estimate the cost of special interconnection studies and equipment (including required modifications to existing B. C. Hydro facilities) as appropriate.

d) Consider alternative price structures and/or financing arrangements, with appropriate guarantees, to assist developments greater than 5MW supplying the integrated system.

e) Wherever possible and using existing facilities, provide standby and emergency service to self-generators and cogenerators with a capacity of more than 5MW, on conditions to be negotiated.

f) Expedite the process of reaching an agreement for the purchase of electricity.

g) Consider special arrangements for those projects which demonstrate new technology or promising significant environmental, social or economic benefits to the Province.

To qualify for a purchase agreement with B. C. Hydro, the IPP must be willing and able to:

a) Demonstrate, preferably through previous experience and/or performance guarantees, an ability to design, finance, construct and operate the proposed project. (B. C. Hydro will be engaging independent financial services to assess the credit worthiness and financial status of the IPP and to analyze the benefits to B. C. Hydro of the proposed project.)

b) Supply his own load requirements at the generating site before selling electricity to B. C. Hydro.

c) Meet electric utility standards for electricity quality, reliability of supply and safety, and be compatible with the B. C. Hydro system.

d) Pay fee(s) to B. C. Hydro (to be stipulated in the RFP) to assist B. C. Hydro in defraying its costs of evaluating the IPP's proposal and conducting technical analyses where required.

e) Pay for interconnection costs and required modifications to existing B. C. Hydro facilities.

f) Retain or otherwise employ a B.C. Professional Engineer with appropriate and relevant experience, to oversee all design aspects of the project and represent the owner/developer on all matters related to construction and performance of the project.

g) Be responsible for all costs incurred in preparing and submitting the proposal, whether or not the IPP is successful in negotiating a contract with B. C. Hydro.

h) Obtain all necessary approvals, licences & permits and comply with all regulatory requirements.

i) Provide a letter or other documentation confirming the land is available for the proposed use, such as IPP ownership of the proposed; an option to purchase; a letter from the Minister responsible if the site is on Crown Land.

## PURCHASE OF LOAD DISPLACEMENT

Purchase arrangements will also be considered for electricity released by load displacement such as self-generation, including cogeneration, as well as energy efficiency measures whereby the same "work" (e.g. lighting or torque) is provided while using electricity more efficiently, ie. using less electricity. For instance, in the first quarter of 1989, Hydro will announce a series of programs under the name 'POWER SMART', to promote the purchase and use of specific technologies, such as:

- Energy Efficient Motors
- Energy Efficient Lighting
- Energy Efficient new building construction

Most of the requirements of an IPP noted above would also apply to respondents on load displacement. Proposals from third parties will be considered but they must be accompanied by written confirmation of the owner's intent to participate in the program.

## REQUESTS FOR PROPOSALS AND THE COMPETITIVE NEGOTIATION APPROACH

For projects of 5MW or more on the integrated system, B. C. Hydro intends to issue RFPs for blocks of firm electricity supply and load displacement, as required, (usually in the fall), and in accordance with the needs of its most recent Resource Plan. B. C. Hydro will commence negotiations with the potential supplier(s) that submits the best proposal. Companies that already have electricity purchase negotiations underway prior to the competition will not be prejudiced by the results of the new negotiation process.

B. C. Hydro will generally take a "Competitive Negotiation" approach to electricity purchase and load displacement. In competitive negotiations, while price is important, there are other key factors to be considered. The competitive negotiation process is iterative, and an initial screening will establish preferred candidates on a short list, on the basis of financial viability, technical merit, the candidate's qualifications, the quantity of electricity being offered or load displaced (ie. its contribution to the aggregate requirement of B. C. Hydro), as well as price.

Simultaneous negotiations will then commence with those on the short list to further refine and adjust the proposals, and to develop a mutually acceptable price and contract betweeen the IPP and B. C. Hydro. Where there is no agreement on price, the IPP will be dropped from the short list, and the next most meritorious IPP, not on the short list, will be admitted into the competitive negotiation process.

This process will continue until B. C. Hydro enters into an agreement to purchase the required amount of electricity and/or load displacement at acceptable prices and under satisfactory conditions.

In-service timing requirements will be included in the RFP, as will specific locations, if required.

## PURCHASE PRICES AND FINANCIAL ARRANGEMENTS

### PURCHASE PRICE FOR ELECTRICITY SUPPLIED TO THE INTEGRATED SYSTEM FOR PROJECTS OVER 5MW

The intent is to negotiate a price that provides the lowest cost to B. C. Hydro ratepayers and reflects the values of firm and secondary energy. In all cases, the purchase price will take into account increases or decreases in B. C. Hydro system transmission and transformer losses caused by the IPP. Loss adjustment and system expansion deferment factors will be determined prior to contract negotiations.

Factors affecting the negotiated purchase price will include:

a) Dependability of annual energy deliveries from the IPP,

b) Reliability of supply,

c) Duration of supply,

d) Dispatchability

e) Impact of the IPP on the transmission and distribution system, eg. effects on cost and timing of system reinforcements or effect on system stability; proximity to the Lower Mainland or Vancouver Island areas.

### PURCHASE PRICE FOR ELECTRICITY RELEASED BY LOAD DISPLACEMENT

The concept of load displacement purchase is new, and notwithstanding the saving in revenue that the customer will receive, B. C. Hydro is still prepared to consider a purchase arrangement for the electricity released by this load displacement. Of particular concern is the difficulty of determining a reasonable rate in the longer term because of the uncertainties in establishing, in fact, what the effective load displacement might be and of monitoring the effects of new technology in the industry concerned. B. C. Hydro will therefore be interested in receiving creative but rational pricing proposal structures.

### POTENTIAL FINANCING ARRANGEMENTS

B. C. Hydro may negotiate financing arrangements that are of benefit to both the respondent and B. C. Hydro. The purpose is to make the project economic and financeable for the respondent without imposing undue risk on B. C. Hydro. Preference will be given to projects entailing the least amount of financial and operational risk to B. C. Hydro. Performance guarantees may be required to reduce risk to B. C. Hydro, both front-end and operational risk. Performance guarantees could include insurance, irrevocable letter of credit, second mortgage or performance bond. It would be the prerogative and responsibility of the IPP or customer to propose preferred financing arrangements.

Financing arrangements will be evaluated on a present worth basis and would be acceptable only if they cause no reduction in B. C. Hydro's net benefit from the project.

## PURCHASES FROM INDEPENDENT POWER PRODUCERS FOR EXPORT SALES

A corporation is being established to manage electricity exports from B.C. This export corporation will be responsible for developing firm sales agreements with U.S. utilities, transmission access and negotiating agreements for export of electricity supplied by IPP's. A separate RFP will be issued for purchase of electricity for the export market, but initially an expression of interest will be issued to explore potential opportunities. RFPs will be issued as market opportunities and transmission access are forecast. The B. C. Hydro process of evaluating an IPP's project for export would be similar to that used for evaluating a project for the domestic market.

## TECHNICAL REQUIREMENTS

### PERFORMANCE OF INDEPENDENT POWER PRODUCERS

The signing of a purchase contract is subject to the capability of B. C. Hydro facilities to accept electricity deliveries from the IPP's plant.

The IPP's plant and output of electricity must not reduce the quality and reliability of B. C. Hydro's customer service. B. C. Hydro will control the operation of the tie line and the amount of delivery as necessary for reliability and security. In some cases, especially for large projects, B. C. Hydro will dispatch plant capacity (ie. control or regulate the plant output) to maintain the standard of service to its customers and to optimize the economical operation of the integrated system.

### CONNECTION TO B. C. HYDRO FACILITIES

Connection of the IPP with B. C. Hydro's integrated system involves technical and safety issues which are described in the B. C. Hydro publications "Interconnection Requirements for Independent Power Producers — 60kV and Higher" and "Interconnection Requirements for Independent Power Producers — below 60kV".

Generally, connection facilities are intended to

a) Provide adequate capacity to deliver the IPP's maximum output to B. C. Hydro.

b) protect the IPP's and B. C. Hydro's equipment, and ensure the safety of workers and the public.

c) maintain high standards of reliability and quality of electricity supply to B. C. Hydro customers.

d) provide metering of the amounts of electricity delivered to B. C. Hydro.

# APPENDIX VII

# TRANSMISSION REQUIREMENTS

This Appendix provides additional information on the system additions listed in Section 5.2 and shown on Exhibit 5-2. Costs shown for projects are in 1988 uninflated dollars, cover all aspects of the project (transmission, stations, communications) and include corporate overhead and interest during construction.

### American Creek Capacitor Station (1990)

This project involves the construction of a series capacitor station near American Creek north of the community of Hope. This station will contain two capacitor banks, one for Nicola-Ingledow and one for Nicola-Meridian. The capacitors will allow increased power transfers to serve new loads in the Lower Mainland and on Vancouver Island.

The total estimated cost for this project is $19 million.

### Puget Sound Power and Light Transmission Intertie (1992)

This project will consist of a 230 kV switching station adjacent to the existing transmission right-of-way in the Fraser Valley in the Aldergrove/ Abbotsford area and two 230 kV transmission lines from there to the international boundary.

Puget Sound Power and Light Company of Bellevue, Washington, has approached B. C. Hydro with a proposal to purchase electricity on a regular basis. A transmission intertie will facilitate the sale of electricity to Puget Power. B. C. Hydro's transmission portion of the intertie is expected to be less than 10 km long. Studies are now under way to identify feasible station sites and route alternatives for the intertie and to prepare the project for regulatory review by the National Energy Board and the provincial Ministry of Energy, Mines and Petroleum Resources. The project will require a Presidential Permit in the United States and Puget Power has started its regulatory study process.

Total B. C. Hydro costs for the project are estimated to be $14 million.

### Static Var Compensator Installations (1993, 1997, 1999)

Static VAR compensators (SVC's) are planned for installation at Malaspina Substation on the Sechelt Peninsula in 1993, at Kelly Lake Substation near Clinton in 1997 and at Nicola Substation near Merritt in 1999. SVC's are electrical devices used to automatically control system voltages to desired levels and to enable the transmission system to transfer more power.

The SVC installations are estimated to cost $19 million each at Malaspina, Kelly Lake, and at Nicola.

### Kitimat-Skeena Transmission Line (1994)

Increased transmission capacity will be required to connect Alcan's Kemano completion project with the B. C. Hydro provincial electric grid. A second 287 kV transmission line is planned between Kitimat Substation and Skeena Substation near Terrace. Total line length will be approximately

50 km. Studies are under way to help determine the best route for the new line.

The estimated total project cost is $14 million.

### Williston-Kelly Lake Transmission Line (1994)

A third 500 kV transmission line is planned between Williston Substation near Prince George and Kelly Lake Substation near Clinton. The project includes a series capacitor bank at or near the existing McLeese capacitor station. Increased system transmission capacity will be required to transmit the additional Kemano power south to the major load centre consisting of the Lower Mainland and Vancouver Island. Total line length will be approximately 330 km and it is planned to be routed on existing right-of-way adjacent to the existing lines between those two substations. Studies are under way to identify potential impacts of the new line and ways to avoiding or mitigating them and to prepare the project for regulatory review under the provincial Utilities Commission Act.

The estimated total project cost is $136 million.

### Kelly Lake-Cheekye Transmission Line (1995)

A second 500 kV transmission line is planned between Kelly Lake Substation near Clinton and Cheekye Substation near Squamish. The project includes a series capacitor bank at or near the existing Creekside Capacitor Station near Pemberton. Load growth in the Lower Mainland and on Vancouver Island, which together constitute approximately 70% of total electrical demand in the B. C. Hydro system, indicates that some new transmission will be needed by about the mid-1990's if that load is to be reliably served. Total line length will be about 200 km depending on the route selected. Studies are under way to identify feasible route alternatives and to prepare the project for regulatory review under the Utilities Commission Act.

The estimated total project cost is $139 million which includes the cost of dismantling one of the existing 230 kV lines between Bridge River and Cheekye to provide part of the right-of-way for the new line.

### Washington Water Power Intertie (1995)

This project will consist of two 230 kV transmission lines from Selkirk Substation east of Trail to the international boundary.

Washington Water Power Company of Spokane, Washington, has approached B. C. Hydro with a proposal to purchase electricity on a regular basis. A transmission intertie will facilitate the sale of electricity to WWP. B. C. Hydro's transmission portion of the intertie is expected to be less than 10 km long. Studies are now under way to identify feasible route alternatives for the intertie and to prepare the project for regulatory review by the National Energy Board and the provincial Ministry of Energy, Mines and Petroleum Resources. The project will require a Presidential Permit in the United States and WWP has started its regulatory study process.

Total B. C. Hydro costs for the project are estimated to be $47 million.

**Nicola-Meridian Transmission Line (1998)**

A second 500 kV transmission line between Nicola Substation near Merritt and Meridian Substation north of Coquitlam is planned. Expectations of continuing load growth in the Lower Mainland and on Vancouver Island indicate that some new transmission will be needed near the end of this century. The new line will be connected into the American Creek Series Capacitor Station. Total line length will be about 250 km depending on the route selected. No route studies are under way for this project but, as a 500 kV transmission line, it will be a regulated project as defined in the provincial Utilities Commission Act.

The estimated total project cost is $149 million.

**Keenleyside-Selkirk Transmission Line (1998)**

A single 230 kV transmission line is planned between Keenleyside generation near Castlegar and Selkirk Substation east of Trail. Total line length will be about 50 km. No route studies are presently under way but route studies were carried out in the past and will be updated prior to making any route decisions. This transmission line will be included in the regulatory review for Keenleyside generation.

Transmission related costs are estimated to be $15 million.

**Site C-Peace Canyon Transmission Lines (1999, 2000)**

Two 500 kV transmission lines are planned between Site C and Peace Canyon generation sites on the Peace River to integrate Site C generation into the provincial electric grid. The first line is scheduled to coincide with Site C completion, with the second following a year later. Total length of each of the lines will be about 75 km and they will be routed on existing right-of-way, now partially occupied by two 138 kV transmission lines. No additional right-of-way will be required. As 500 kV lines and as ancillary facilities to the Site C development, these lines will be regulated under the provincial Utilities Commission Act.

Transmission related costs are estimated to be $78 million.

# APPENDIX VIII

# VALUE OF POWER

## LONG-TERM UNIT ENERGY COSTS

### B. C. Hydro uses long-term unit energy costs to compare projects

The long-term unit energy cost of a project is the expected average cost (in the current year's constant dollars) of energy produced by the project over its lifetime. It is computed as follows:

1. The uninflated construction cost of the project, including associated transmission, is estimated in the current year's dollars in the form of annual disbursements. In most cases these estimates include expenditures that would be incurred during the planning and licensing period prior to project construction.
2. An allowance for corporate overheads is added to the construction cost estimate.
3. Interest during construction is accumulated up to the in- service date at the selected net discount rate.
4. The total capital cost is then computed as the sum of the construction cost, corporate overhead and interest during construction.
5. Annual interest and depreciation costs (sinking fund) over the project's assumed lifetime are computed from the total capital cost using the selected discount rate.
6. Other annual costs, which would be incurred during the life of the project, such as operating, maintenance, administration, interim replacement and other costs are estimated. Usually these are calculated as a percentage of total construction costs of various types of plant. Estimates are also made for fuel costs and variable maintenance charges as applicable.
7. The total annual cost is computed as the sum of interest and depreciation costs, fixed annual costs and variable annual costs (including fuel).
8. The long-term unit energy cost is then computed as the ratio of the project's total annual costs to the project's average annual energy output.

## LONG-TERM AND SHORT-TERM MARGINAL VALUE OF POWER

### B. C. Hydro uses long- term value of power for generation, transmission and other optimization studies

The long-term value of power is a single value of energy and capacity that is based on the time-weighted average cost of projects included in the Resource Plan. Because of the uncertainty on the timing and cost estimates of many of the later projects in the Resource Plan, power values are estimated for several alternative development options and the results are then averaged.

The short-term marginal value of power is set by calculating the incremental and decremental production costs of 1000 GWh to the in-service date of the next plant. Short-term values are used for evaluating short-term project modifications as well as evaluating potential power purchases and coordination agreements with other power producers.

Long-term and short-term values of power, based on October 1988 cost estimates at a 6% net discount rate are as follows:

| | Long-Term Value of Power | |
|---|---|---|
| | Excluding Taxes | Including Taxes |
| Peak capacity ($/kW/year) | 19.0 | 24.0 |
| (equivalent ¢/kWh) | 0.4 | 0.5 |
| Firm Energy (¢/kWh) | 2.8 | 3.3 |
| Firm Energy and Capacity (¢/kWh) | 3.2 | 3.8 |
| Secondary Energy (¢/kWh) | 2.0 | 2.3 |

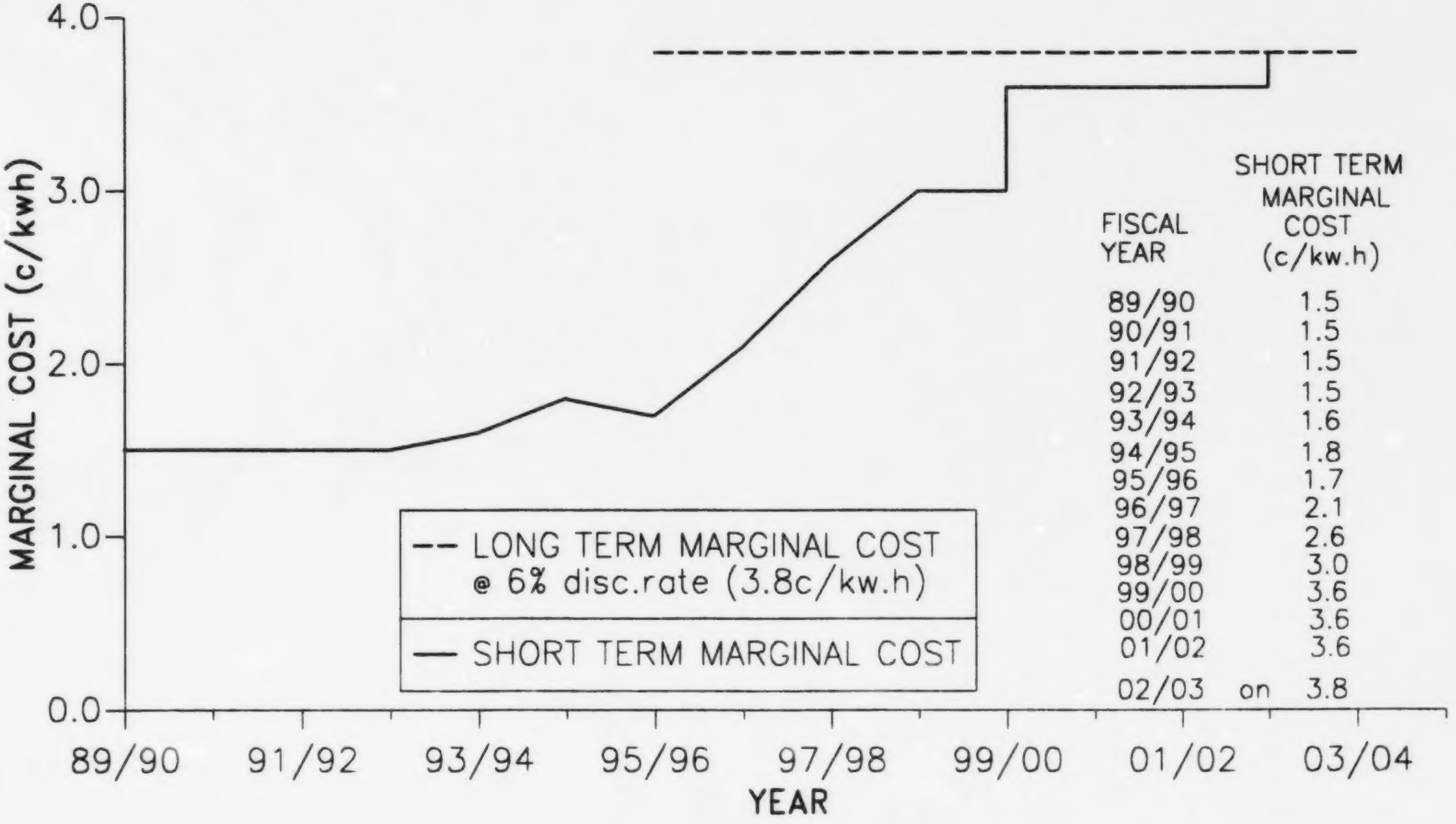
Short-term values of power are summarized below:

| Fiscal Year | Short-Term Marginal Value of Power (¢/kWh) |
|---|---|
| 1989/90 | 1.5 |
| 1990/91 | 1.5 |
| 1991/92 | 1.5 |
| 1992/93 | 1.5 |
| 1993/94 | 1.6 |
| 1994/95 | 1.8 |
| 1995/96 | 1.7 |
| 1996/97 | 2.1 |
| 1997/98 | 2.6 |
| 1998/99 | 3.0 |
| 1999/00 | 3.6 |
| 2000/01 | 3.6 |
| 2001/02 | 3.6 |
| 2002/03 on | 3.8 |

Exhibit VIII-1 shows values of power for the period 1989- 2001, and the estimated long-term value of power after 2002.

**EXHIBIT VIII - I**

# MARGINAL COST OF POWER *
## B.C. Hydro Integrated System



| FISCAL YEAR | | SHORT TERM MARGINAL COST (c/kw.h) |
|---|---|---|
| 89/90 | | 1.5 |
| 90/91 | | 1.5 |
| 91/92 | | 1.5 |
| 92/93 | | 1.5 |
| 93/94 | | 1.6 |
| 94/95 | | 1.8 |
| 95/96 | | 1.7 |
| 96/97 | | 2.1 |
| 97/98 | | 2.6 |
| 98/99 | | 3.0 |
| 99/00 | | 3.6 |
| 00/01 | | 3.6 |
| 01/02 | | 3.6 |
| 02/03 | on | 3.8 |

* Energy and capacity in 1988 dollars

# GLOSSARY

**AVOIDED COST:** Cost of the facilities that would have to be built, or the energy purchases that would have to be made, to supply a certain demand, and that can be saved by introduction of an energy efficiency program.

**CAPABILITY:** The energy output of a generating station or the integrated system under specified conditions for a given time interval (usually one year).

**CAPACITY:** Pertaining to the rating of the output from a generating station or the system.
- Maximum - the maximum output which can be achieved.
- Nameplate - the maximum output specified by the manufacturer.
- Dependable - the maximum output that can be supplied during peak load months (December and January) on a reliable basis.
- Firm - based on dependable capacity, unit availability and system characteristics; computed from reliability analyses.

**COGENERATION:** The simultaneous production of mechanical or electrical energy and useful thermal energy in the form of steam or hot water from a single fuel source.

**COORDINATION:** Pooling of resources and loads between utilities to allow more efficient use of resources. Coordination, involving joint reservoir management, may increase the annual availability of firm energy from the existing hydroelectric plants in the B. C. Hydro system. It may enable each participating utility to defer new power plant construction. Coordination agreements with other producers, such as Bonneville Power Administration, Transalta, and Alcan, are an important part of Power Smart.

**COMMERCIAL SECTOR:** Service industries including retail, community, transportation, communications, construction and other utilities.

**CRITICAL WATER CONDITIONS or CRITICAL WATER SEQUENCE:** A period of adverse streamflows which actually occurred in the past. Critical water conditions serve as a design test of the capability of a hydroelectric system to meet forecast electric loads under adverse reservoir inflows. During a critical period all hydroelectric reservoirs would be drawn down to minimum levels in order to sustain service.

**DEMAND:** The amount of electricity required by the system or by the customers.

**DEMAND-SIDE MANAGEMENT:** Actions that influence energy demand to better match energy supply. In B. C. Hydro's case, Power Smart customer programs promote efficient energy consumption to reduce future demand so that the construction of power plants can be delayed. In this way the cost of electricity is kept in check.

**DISPATCHABLE:** The ability to regulate electrical deliveries to the utility system requirements.

**FINANCEABLE:** Sufficiently secure to permit the proponent to obtain financing for his or her project.

**FIRM ENERGY:** The assured energy contribution (kW.h) of generating plants over one year. For the

B. C. Hydro system the firm energy capability is based on the energy available during an extended period of adverse streamflows (the critical period).

**GIGAWATT HOUR (GW.h):** One million kW.h. Hydro measures the energy output of generating stations in gigawatt hours.

- City of Vancouver uses 4000 GW.h each year.
- Prince George uses 2000 GW.h each year, half of which goes to its industrial customers.
- Victoria uses approximately 690 GW.h per year.
- Vernon uses 180 GW.h per year.

**INDEPENDENT POWER GENERATION:** Electricity generation from an independent or privately-owned facility which is connected to the Hydro system. Includes self-generation and cogeneration where there may be no net sale of electricity to Hydro.

**INDEPENDENT POWER PRODUCER:** A person or company whose independent generating facility is connected to a utility system such that electricity may be sold to and purchased from the utility.

**INDUSTRIAL SECTOR:** Manufacturing industries including pulp and paper, wood products, mining, metals and coal, and chemical and petroleum products.

**INTEGRATED SYSTEM:** The interconnected network of transmission lines and substations linking generating stations to one another and to customers. Also representing that portion of the B. C. Hydro electric system capable of being operated on a coordinated basis.

**INTERCONNECTION FACILITIES:** Components in the substation (and transmission in some cases) that connect the IPP generator to the B. C. Hydro system, plus any other facilities required to integrate the IPP generator with the B. C. Hydro system.

**LEVELIZED COSTS:** Typically, alternative programs will vary in the amount and timing of capital expenditures and costs of operation. To facilitate comparisons these costs may be levelized over a specific time period. The levelized cost is the uniform annual payment that has the same present worth as the varying cost string for this time period.

**LOAD:** The amount of electricity required by a customer or group of customers.

**LOAD DISPLACEMENT:** The freeing of electricity from an existing customer's load (future or present) by using electricity more efficiently to perform the same amount of work (i.e. lighting, torque, etc.), or by the addition of customer self-generation.

**LOAD SHIFTING:** Switching load from times when demand is heavy to times when it's light.

**MEGAWATT:** 1000 kW, commonly used to measure the capacity of generating stations.

**NON-INTEGRATED AREAS:** B. C. Hydro service areas, remote from the integrated system and usually supplied by a local diesel generator.

**PARALLEL GENERATION:** Electricity generated by an independent power producer's facility connected to a utility system. It includes customer-owned generation where surplus electricity may be sold to the utility.

**PEAK DEMAND:** The maximum amount of electricity required by the system or by the customers, averaged over one hour, usually in the evening.

**POWER SMART:** Collective name given to B. C. Hydro's energy efficiency strategy including marketing and the measures which increase the net output of existing B. C. Hydro generating stations. The reduction in future additional demand will help to defer large capital outlays and finance charges associated with new power plant construction.

**PRESENT WORTH:** The present sum which, if deposited with interest at a given rate, would exactly provide funds for a scheduled future payment or series of payments.

**REQUEST FOR PROPOSAL:** Document(s) issued by B. C. Hydro describing the necessary arrangements for the utility to purchase electricity supply (or load displacement) from private power producers.

**RESIDENTIAL SECTOR:** All single electric metered dwellings occupied by customers, and used as residences.

**SECONDARY ENERGY:** The energy that is available when water conditions are such that there is more than enough water in the reservoirs to meet firm requirements of regular customers. Secondary energy is not guaranteed to always be available.

**SELF-GENERATION:** Generation of electricity by a customer for its own use, which could include cogeneration.

**STRATEGIC CONSERVATION:** Reduction in demand for electricity, usually to delay the need for new facilities.

**STRATEGIC LOAD GROWTH:** Encouragement of more electrical use through short-term marketing programs at key periods, such as when new generating facilities come into service.

**SUPPLY-SIDE OPTIONS:** Generic denomination including all alternatives that increase generation output, such as new generation projects, coordination and purchases, and improvements to existing facilities.

**TRANSMISSION LOSSES:** Losses of electricity caused by line resistance, transformation, etc.

**WATER LICENCE FEE:** Annual payment to the Provincial Government in respect to the amount of electricity generated, the acres of land flooded, the installed plant capacity plus other charges for storage, etc. Also known as water rental fees.

**WHEELING:** The transmission of electric power from one system to another (often a producer to a consumer) through a third party (usually the owner of the transmission facilities).

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